THE RESOURCES AGENCY OF CALIFORNIA

Department of Water Resources

BULLETIN No. 111

SACRAMENTO RIVER WATER POLLUTION SURVEY

APPENDIX D
BENTHIC BIOLOGY

AUGUST 1962

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
Administrator
The Resources Agency of California
and Director
Department of Water Resources

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ACKNOWLEDGMENTS

A biological study of the scope attempted in the Sacramento River Water Pollution Survey requires the efforts of many people. Special thanks are due to Marvin Peyton of the Department of Water Resources, who assisted in most of the field collections upon which this report is based.

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Mrs. Evelyn Oathout, Librarian, provided invaluable assistance in obtaining references to resolve taxonomic difficulties.

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CHAPTER I. INTRODUCTION

It is necessary to examine all aspects of water quality to gain a clear understanding of past and present characteristics of a stream. Chemical and physical measurements provide data on water conditions at a particular moment. On the other hand, biological observations reflect conditions that have existed for some time previously. A study of biological characteristics and the ecological relationships of plants and animals in a stream may therefore provide the best overall picture of past and present water quality conditions in that stream.

Various assembledges of organisms are known to be associated with particular types of water quality. For example, heavy concentrations of midge larvae or tubificid worms are often associated with organic enrichment. These organisms are quite tolerant of low dissolved oxygen concentrations and, in the absence of competition from other tolerant forms, may increase their numbers enormously. On the other hand, waters with little pollution may be characterized by smaller total numbers, but a much greater variety of animals. Thus, in clean-water streams, we may expect to find organisms such as mayflies, stoneflies, caddisflies, midge larvae, damselflies, and a host of other types. It must be noted, however, that aquatic forms often associated with poor water quality are also found in clean water areas but are far less numerous.

In addition to effects brought about by the chemical quality of water, the physical characteristics of the habitat are extremely important in modifying plant and animal life. Certain types of habitat are not conducive to large bottom fauna populations. A shifting sand bottom, for example, supports a much smaller biomass than does a silt or boulder habitat.

It should be apparent, from the foregoing statements, that careful interpretation of the data collected is extremely important in assessing the relationship between aquatic life and its environment. In this respect, the more factors that can be measured, and the more data on hand, the more meaningful this interpretation can become. Therefore, as time permitted, data from other segments of the Sacramento River investigation were used to supplement those gathered in the biological survey.

Because of time limitations, it has not been possible to make a complete ecological interpretation of the data collected during the biological phase of the Sacramento River Water Pollution Survey with data from other portions of the investigation.

Authorization of Study

The biological survey was conducted by personnel of the Departments of Water Resources and Fish and Game in accordance with Interagency Agreements No. 25141 and No. 25093.

Objectives and Scope of Study

The biological portion of the Sacramento River Water Pollution Survey was designed to: (1) establish a "base-line" of present biological conditions against which future changes can be measured, and (2) provide information necessary for setting waste discharge requirements for the protection of aquatic life.

In order to meet these objectives, biological sampling was conducted at monthly intervals from April 1960 through June 1961 at twenty-two "key" sampling stations from Shasta Dam to the confluence of the Sacramento and San Joaquin Rivers (Plate 1). Seven additional river stations were established to measure biological conditions in areas of particular interest. Two large agricultural irrigation drains were also sampled during periods when they carried large amounts of drainage water.

It became apparent at about the middle of the field-collecting phase of the investigation that, with the resources at hand, the laboratory work would not be completed in the time available. The biological program was therefore reduced by approximately one-third for the remainder of the investigation. This was accomplished by discontinuing some stations, and sampling on a bimonthly basis at certain others.

In addition to sampling of bottom organisms and attached plants, the following measurements were made: temperature of water and air; weather conditions; dissolved oxygen at the surface and at the bottom of the river; dissolved oxygen in the gravels at selected locations known to be important for fish spawning activities; water transparency; plankton samples; and bottom sediment sizes. No attempt was made to collect or evaluate fish populations during the investigation.

CHAPTER II. METHODS

The methods used during this survey were, whenever, possible, adopted from procedures outlined in "Standard Methods" (1960), or Welch (1948).

Field Investigations

Sampling Stations

The locations of sampling stations are shown on Plate 1. Detailed maps showing locations of individual samples from each of the stations are on file at the Department of Fish and Game Field Station at Sacramento. Station descriptions are summarized below; unless otherwise stated, stations are on the Sacramento River.

Station 305.7 (Above Spring Creek). Keswick Reservoir near Matheson. Samples from 36 to 50-foot depths near banks. Fine sand and silt, frequently with large amounts of organic debris.

Station 297.7 (Above Redding Diversion Dam). Samples from 1.5 to 11-foot depths. Large cobbles.

Station 295.2 (Redding F & G Station 1). Shallow pits in flood plain. Samples from 9 to 13-foot depths. Sandy silt with organic debris overlying cobbles.

Station 294.0 (Above Cypress Avenue Bridge, Redding). Samples from 1.5-foot depth in riffle area near bridge and along right bank 0.3 mile upstream. Large cobbles with some sand.

<u>Station 285.9 (Above Churn Creek)</u>. Riffle area. Samples from 1.5-foot depth near center of river. Cobbles, average 3-inch diameter.

<u>Station 279.2 (Above Cow Creek)</u>. Near Anderson. Samples from 1.5-foot depth. Gravel.

<u>Station 275.0 (Balls Ferry Bridge)</u>. Samples from 1.5-foot depths in riffle area near right bank. Cobbles, average 5-inch diameter.

<u>Station 256.3 (Bend Bridge)</u>. Samples from 1.5-foot depth near left bank at first riffle downstream from bridge. Cobbles, average 30inch diameter.

<u>Station 253.4 (Big Bend)</u>. Narrow, deep channel with boulders. Samples from 1.5 to 20-foot depth near right bank.

<u>Station 241.0 (Below Red Bluff)</u>. Broad, shallow channel. Samples from 1.5 to 6-foot depth along right bank in riffle area and in backwater. Gravels in riffle, silt and fine sand in backwater.

<u>Station 229.8 (Above Elder Creek)</u>. First riffle upstream from confluence. Samples from 1.5-foot depth near island. Sandy gravel.

<u>Station 217.6 (Vina Bridge)</u>. Samples from 10 to 20-foot depths throughout stream. Sand and silty sand.

<u>Station 199.6 (Hamilton City Bridge)</u>. Leveed section upstream from bridge. Samples from 5 to 11-foot depths, generally near banks. Gravel and cobbles at midstream, sand and silt near banks.

<u>Station 184.5 (Ord Ferry)</u>. Samples from 6 to 12-foot depths upstream from ferry, generally near right bank. Silt and clay near right bank, sand in rest of stream bottom.

Station 168.2 (Butte City). Samples collected from 7 to 25-foot depths, generally near banks. Sand in midstream, silt and clay near banks.

Station 144.1 (Colusa Bridge). Leveed section. Samples from 10 to 18-foot depths. Sand.

Station 118.1 (Wilkins Slough). Leveed section. Samples from 10 to 26-foot depths. Clay to medium sand.

Station 90.5 (Above Colusa Basin Drain). Leveed Section. Samples from 18 to 22-foot depths. Sand in central portion, fine sand and silt near right bank.

Station 90.2R/0.1 (In Colusa Basin Drain). Samples from 7 to 10-foot depths about 500 feet below dam. Coarse sand and plant debris.

Stations 88.2 and 88.8 (Below Knights Landing). Leveed section. First two samples from lower station. Samples from 10 to 25-foot depths. Generally sand bottom, some fine sand and silt.

Station 81.5 (Above Sacramento Slough). Leveed section. Samples from 14 to 28-foot depths. Fine sand near midstream, hard clay near right bank.

Station 80.8L/0.1 (In Sacramento Slough). Samples from 11 to 20-foot depths. Silt and clay.

Station 62.6 (Bryte). Leveed section. Samples from 10 to 48-foot depths. Sand near midstream, clay near left bank.

Station 53.2 (Clay Bank Bend). Leveed section, about 1/2 mile below Sacramento Sewage Treatment Plant Outfall. Samples from 14 to 22-foot depths. Sand and organic debris.

Station 46.4 (Freeport). Leveed section. Samples from 15 to 23-foot depths. Sand near midstream, silt near banks.

Station 43.4 (Above Clarksburg). Leveed section with occasional tidal flow reversals. Samples from 16 to 45-foot depths near banks.

Station 37.2 (Snodgrass Slough). Leveed section. Samples from 16 to 34-foot depths. Sand near midstream.

Station 27.4 (Above Delta Cross Channel at Locke). Leveed section. Samples from 17 to 25-foot depths. Sand near midstream, silt and clay near banks.

Station 18.8 (Isleton). Leveed section with strong tidal flow reversals. Samples from 10 to 16 feet, generally near right bank. Sand near midstream.

Station 12.8 (Below Rio Vista Bridge). Leveed section about 0.4 mile wide. Samples from 14 to 24-foot depths. Silty sand with some organic debris.

Station 4.0 (Above Mayberry Slough). About 0.5 mile wide, hills near right bank, left bank leveed. Samples from 25 to 35-foot depths. Sand and silt with large amounts of organic debris.

Physical Determinations

Temperature. Air and water temperatures were determined with the use of a 5-1/2 inch mercury-filled thermometer graduated in degrees Fahrenheit and recorded to the nearest degree. Air temperatures were taken in the shade one or two feet above the water surface, holding the thermometer at least two feet away from any object. Water temperatures were determined by immersing the bulb in the stream until the mercury column exhibited no movement.

Temperatures of bottom waters or waters in the gravels were obtained immediately from 300-milliliter sample bottles.

Dissolved Oxygen. Dissolved oxygen determinations were made, using the Alsterberg (azide) modification of the Winkler method. Water was collected by means of a 2-liter Kemmerer water sampler at most stations. Surface dissolved oxygen samples were taken at approximately one- to two-foot depths. Bottom dissolved oxygen samples were taken from as near the bottom as possible. At sandy or gravel bottoms, the sampler was allowed to touch bottom, then the messenger released to trip the valves. Over mud or silt bottoms, samples were taken from about one foot off the bottom to eliminate collecting bottom material.

Water samples were collected by a different method at the stations between mile 294 and mile 229.8 where sampling was done in shallow water (one to two feet deep). Water was drawn into a 300-milliliter bottle by evacuating air from the bottle with a tube, causing a partial vacuum and pulling water into the bottle through another tube. Samples at these stations were taken at a depth of one inch from the surface, within one inch of the bottom, and, when possible, at a depth of 12 inches in the gravel. In the latter case, water was withdrawn from a perforated pipe which was driven into the gravel.

Transparency. Water transparency was measured with a 20-centimeter Secchi disc. The depths at which the disc disappeared from sight and subsequently reappeared were recorded. The average of these two distances is considered the limit of visibility.

Bottom Particle Size. Stream bottom particle size was determined by two methods. Particle sizes were measured at the riffle stations with a 100-foot tape and graduated calipers. The tape was stretched across gravel which was judged representative in composition to that being sampled for bottom organisms. The intermediate axis of the gravel particle located directly under each foot-mark was measured by the use of calipers graduated in millimeters (Wolman, 1954). This method is useful in comparing the relative size of gravel in different areas, but has the disadvantage of not measuring the amount of sand and silt in the gravel.

Bottom sediment samples were taken at stations other than those located on riffles with a Petersen dredge. A pint sample of the material collected was retained and sent to the Department of Water Resources Soils Laboratory for determination of particle size distribution.

Biological Collections

Plankton. Quantitative plankton samples were taken from various stations throughout the survey. These samples were collected with a Kemmerer water sampler. Three samples were taken at midstream and at the quarter points across the river at a depth of two to three feet. The samples were composited in a one-gallon jug and fixed by adding sufficient formalin to result in a four percent solution.

Beginning in September 1960, two samples were taken at each station at third-points and composited in a half-gallon bottle.

All of the samples were sent to the Department of Public Health, Sanitation and Radiation Laboratory, Berkeley, for identification and enumeration. The results of this study are reported in Appendix C.

Attached Plants. Attached plants were collected at several locations by pulling the entire plant loose from the subtrate and preserved in approximately five percent formalin solution.

Bottom Organisms. Bottom organisms were collected by means of a Surber sampler or dredge. Collections were made with a one square-foot Surber sampler at miles 297.7, 294, 285.9, 279.2, 275, 256.3, 253.4, 241.0, and 229.8. Three samples were taken on most occasions at these stations. The entire contents in the sampler, which included organisms, detritus, sand, small gravel, etc., were labeled and preserved in 10 percent formalin.

A Petersen dredge was used to collect bottom organisms at all of the stations other than those listed above, from May 1960, through the end of the sampling program. Station depths ranged from 4 to 30 feet. The area sampled by this dredge was 96 square inches, or approximately two-thirds square foot. From one to three dredge hauls were made for each collection. Attempts at using an Ekman dredge were unsuccessful.

Samples collected with the dredge were poured into soil sieves with openings of 0.589 mm (Standard U. S. Sieve No. 30). The organisms remaining on the screen were picked off with forceps, placed in vials, together with appropriate labels, and preserved in a 10 percent formalin solution.

Laboratory Procedures

Bottom Organisms

Bottom organism samples were delivered to the Bryte Laboratory of the Department of Water Resources for analysis. Samples of bottom organisms were placed in Petri dishes and examined under a binocular dissecting microscope.

The animals were separated into the lowest most easily recognizable taxonomic group, and placed by group in Syracuse watch glasses for more refined determinations. Each group was then more closely examined and identified to the lowest possible taxonomic unit (e.g. genus and/or species). After identification, the numbers and volume of each kind of organism were tabulated. The sample material was then placed in a vial, together with a collection data slip, and preserved in alcohol for permanent storage. The laboratory form, storage vial, and collection data slip all have the same inscribed number so that cross references can be made. These samples are stored by the Department of Fish and Game at the Sacramento Field Station, and are available for future reference.

Two measurements were used in the quantitative analysis of the bottom fauna samples. These included numbers and volume of individuals. The volume of displacement was calculated by placing the portion of the sample to be measured on absorbent paper toweling and permitting the individuals to dry for one-half to one minute. A measured amount of distilled water was pipetted into a graduated cylinder. The blotted animals were then admitted. The volume of the organisms was recorded in cubic centimeters.

Bottom Sediment Size

Particle size analyses of bottom sediment samples were made in accordance with the procedure given in the Department of Water Resources'

"Manual of Testing Procedures for Soils", dated April 1962. Essentially this consists of taking a 100-gram aliquot from the sample and shaking this portion through a nest of sieves. The sieves used are United States Standard Sieves Nos. 8, 16, 30, 50, 100 and 200, and a pan. A lid is placed on the top sieve and the complete nest of sieves is shaken for about 30 seconds. The No. 8 sieve is then carefully removed from the other sieves, placed on an extra pan, and vibrated vigorously in a circular motion while being tapped on the side with one hand. This shaking is continued until all of the material finer than the No. 8 has passed the sieve. When this sieving is complete, the material retained is emptied into a pan, and the material that passed through the sieve is placed in the next smaller mesh sieve. This screening procedure is repeated for each sieve size and the weight of material retained on each sieve is determined and recorded.

Size distributions of material that passed through the No. 200 screen were determined with a hydrometer.

CHAPTER III. PHYSICAL CHARACTERISTICS

Physical characteristics of Sacramento River water were determined at the times of biological sampling. The results, which were generally consistent with those obtained during the water quality portion of the investigation (Appendix B), are summarized below.

Temperatures and Dissolved Oxygen

Figures 1 through 8, inclusive, show air and water temperatures, surface and bottom water dissolved oxygen concentrations, and dissolved oxygen concentrations in interstitial waters of gravels. Figures 9 and 10 show that the oxygen data are consistent with values obtained during other phases of the investigation.

Water temperatures at Keswick (mile 305.7) were generally about 50°F. Downstream water temperatures approached equilibrium with air temperatures at varying rates.

Dissolved oxygen concentrations increased during the first 15 to 25 miles below Keswick and then generally decreased throughout the rest of the river (Figures 9 and 10). Surface and bottom dissolved oxygen levels were generally about the same; of the 330 observations, significantly lower concentrations at the bottom occurred only about two percent of the time.

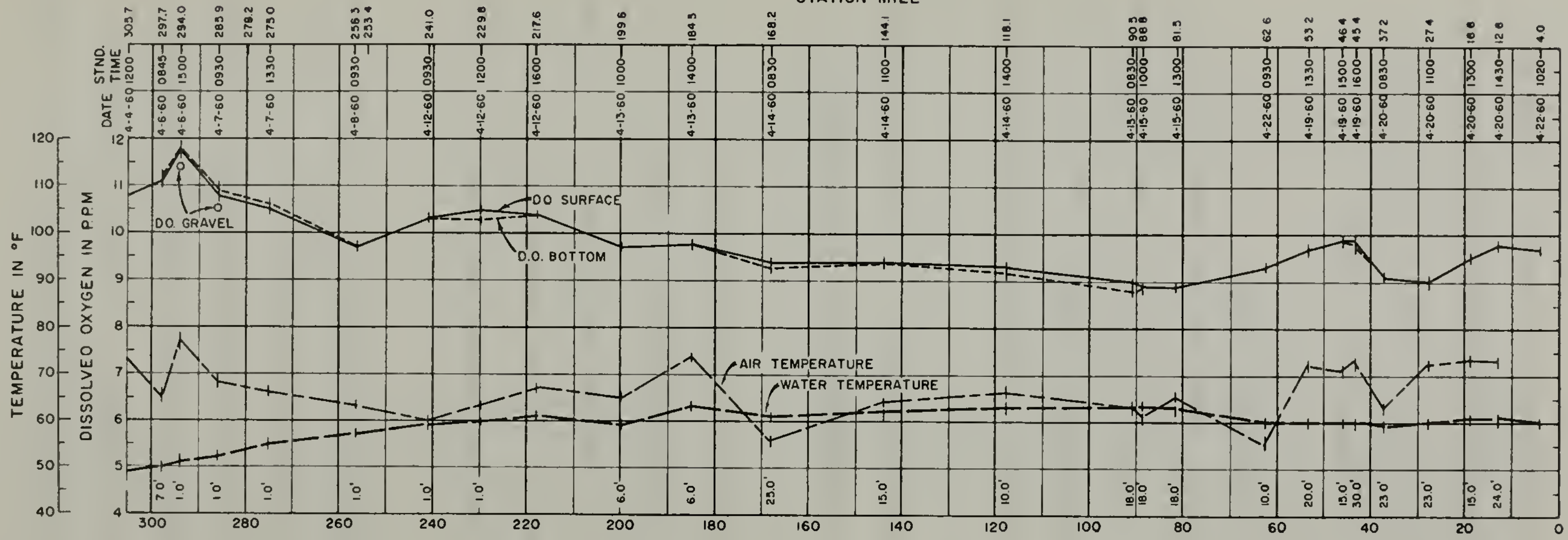
Within the gravels in riffle areas, oxygen concentrations varied from about 4 to 12 ppm with average values about 2 ppm less than those in the overlying water (Figure 11). Wide variations were noted between closely spaced sampling points, with lower values generally associated with greater percentages of fines in the gravel. This may explain why successful salmon spawning occurs in very localized areas within a general spawning reach.

FIGURE I

SACRAMENTO RIVER WATER POLLUTION SURVEY

BIOLOGICAL SURVEY-PHYSICAL DATA

APRIL 1960



MAY 1960

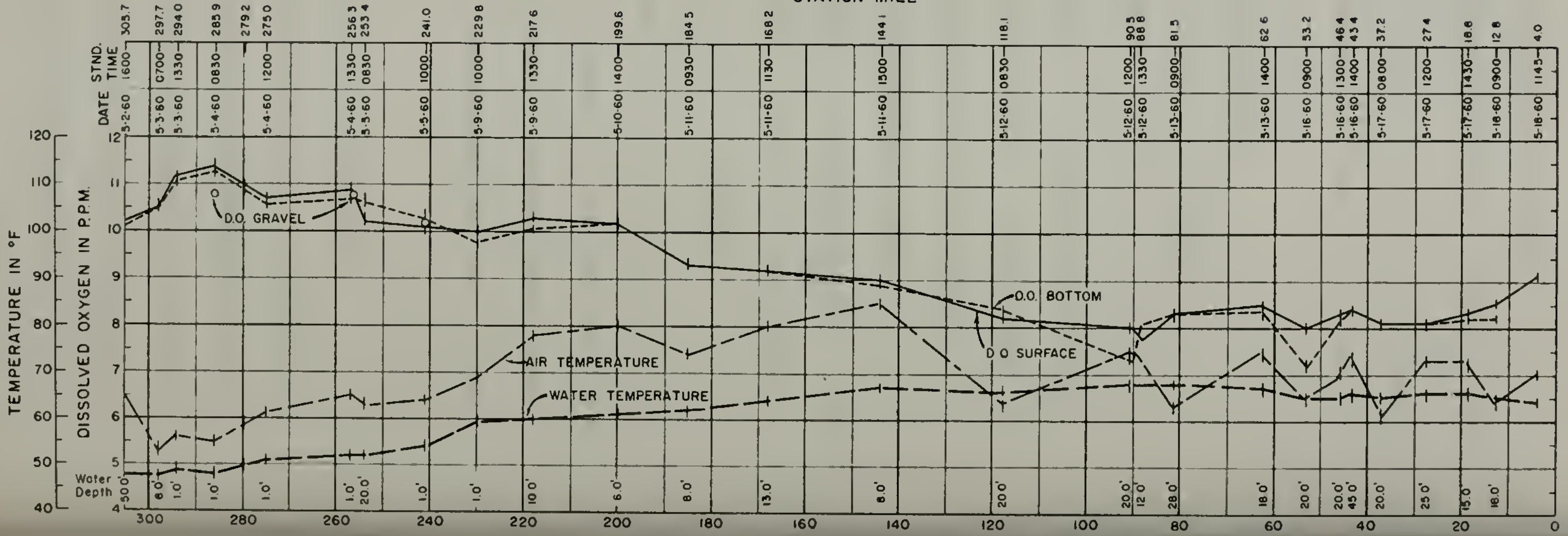


FIGURE 2
SACRAMENTO RIVER WATER POLLUTION SURVEY
BIOLOGICAL SURVEY-PHYSICAL DATA
JUNE 1960

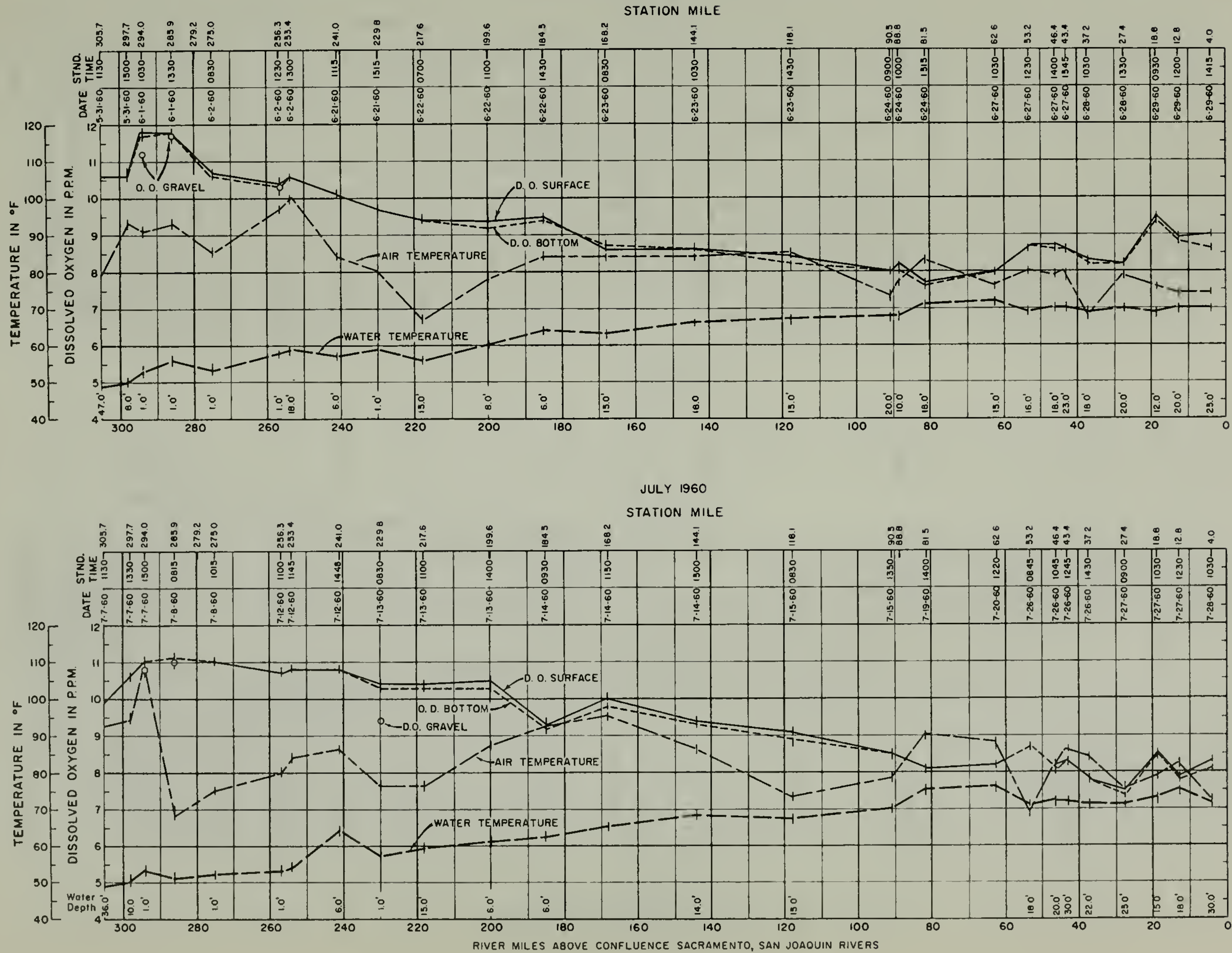


FIGURE 3

SACRAMENTO RIVER WATER POLLUTION SURVEY

BIOLOGICAL SURVEY-PHYSICAL DATA

AUGUST 1960

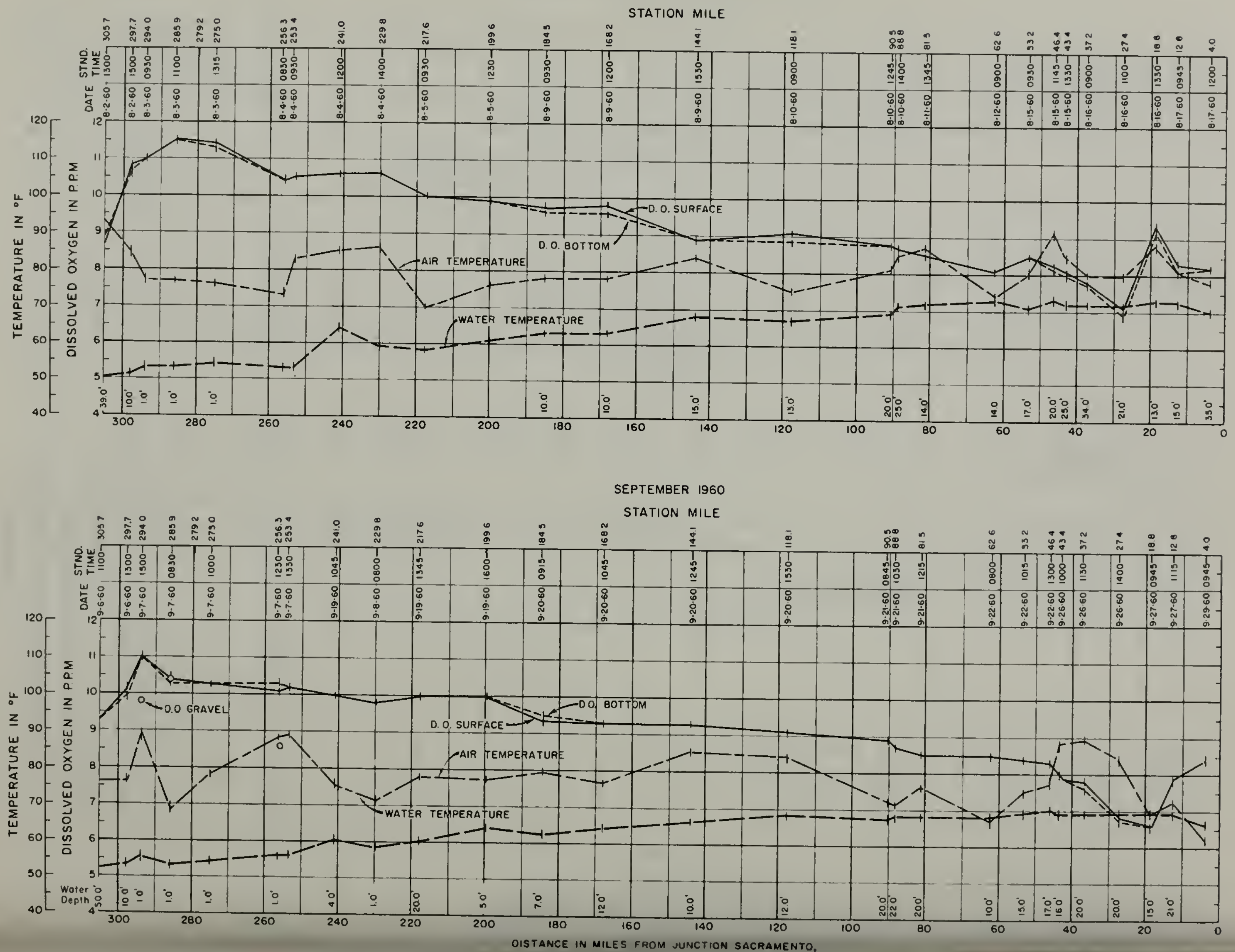
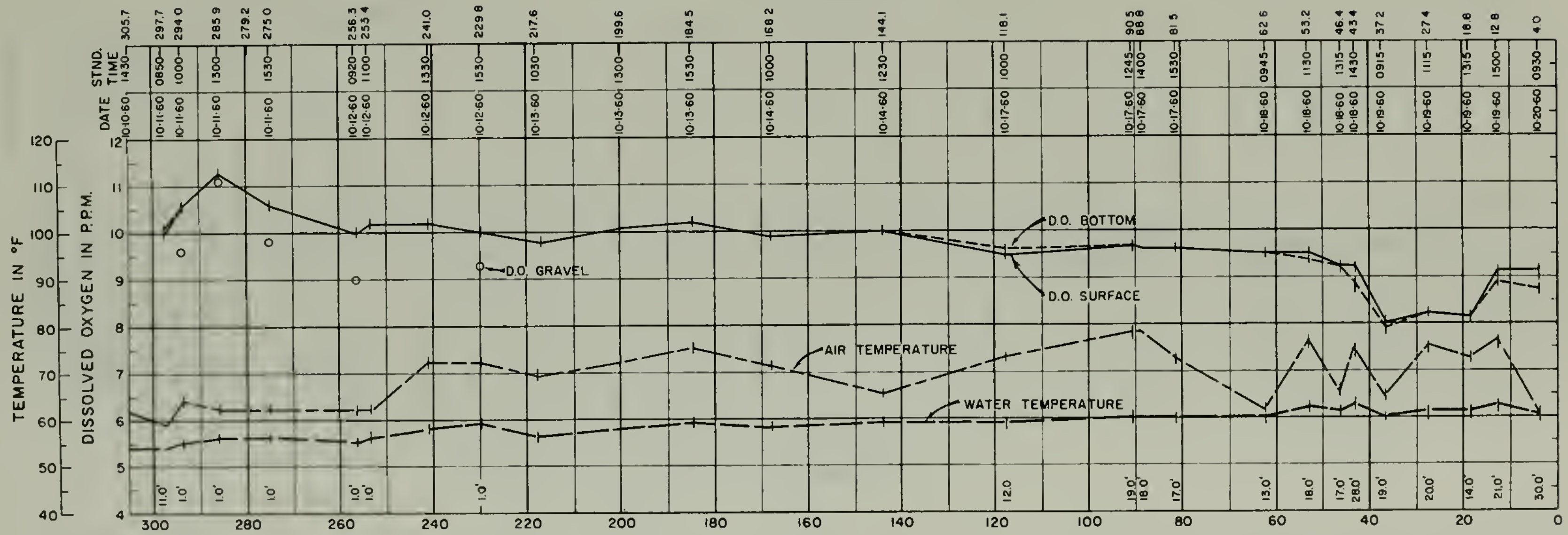


FIGURE 4

SACRAMENTO RIVER WATER POLLUTION SURVEY

BIOLOGICAL SURVEY-PHYSICAL DATA

OCTOBER 1960



NOVEMBER 1960

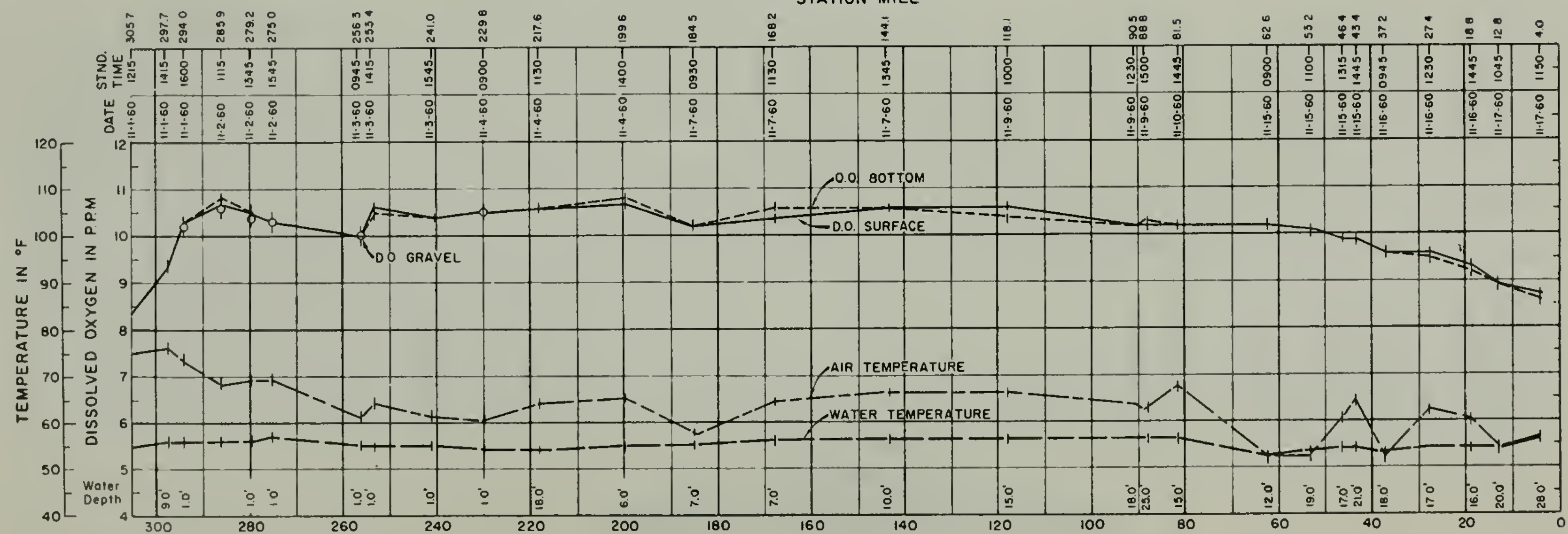


FIGURE 5
SACRAMENTO RIVER WATER POLLUTION SURVEY
BIOLOGICAL SURVEY - PHYSICAL DATA

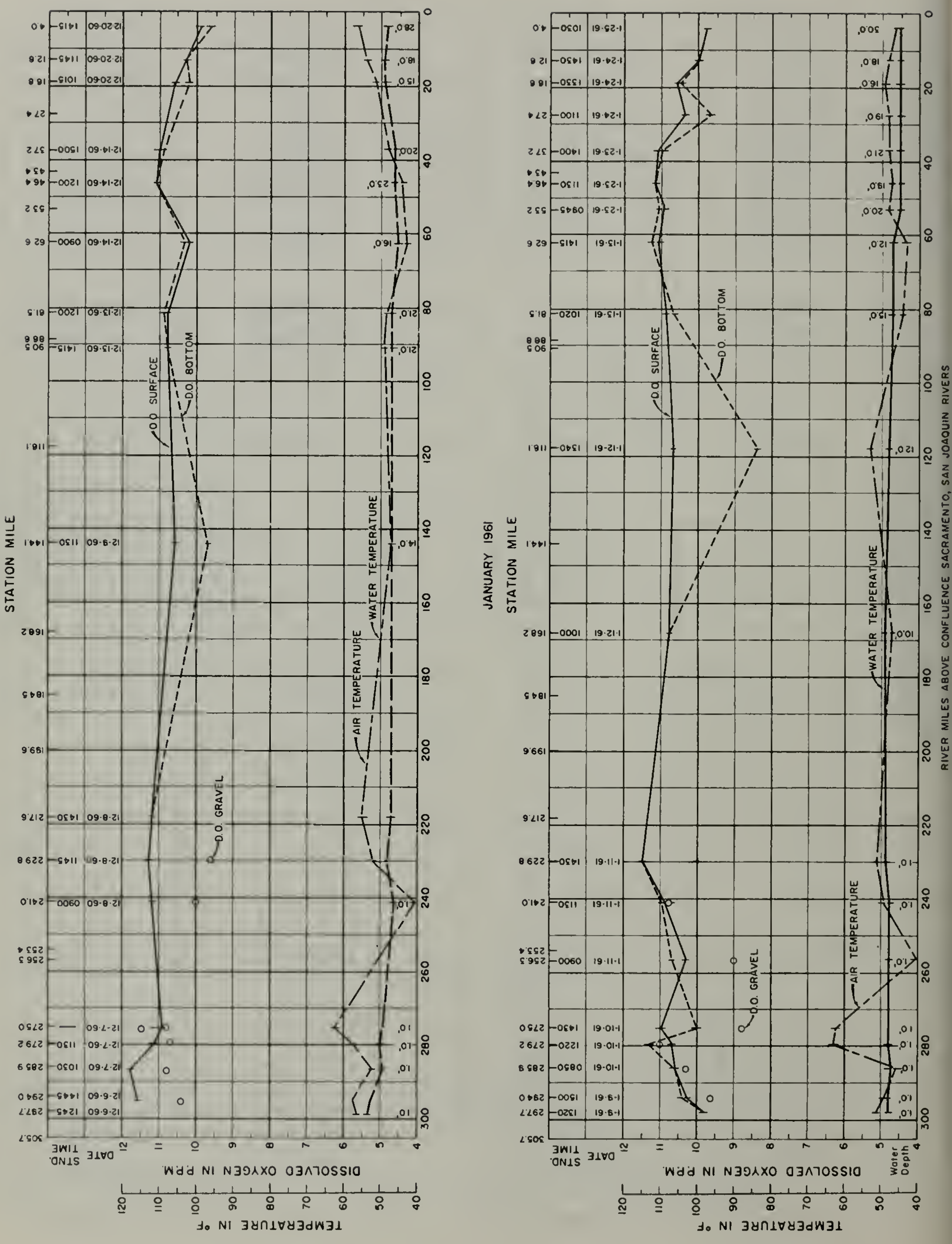
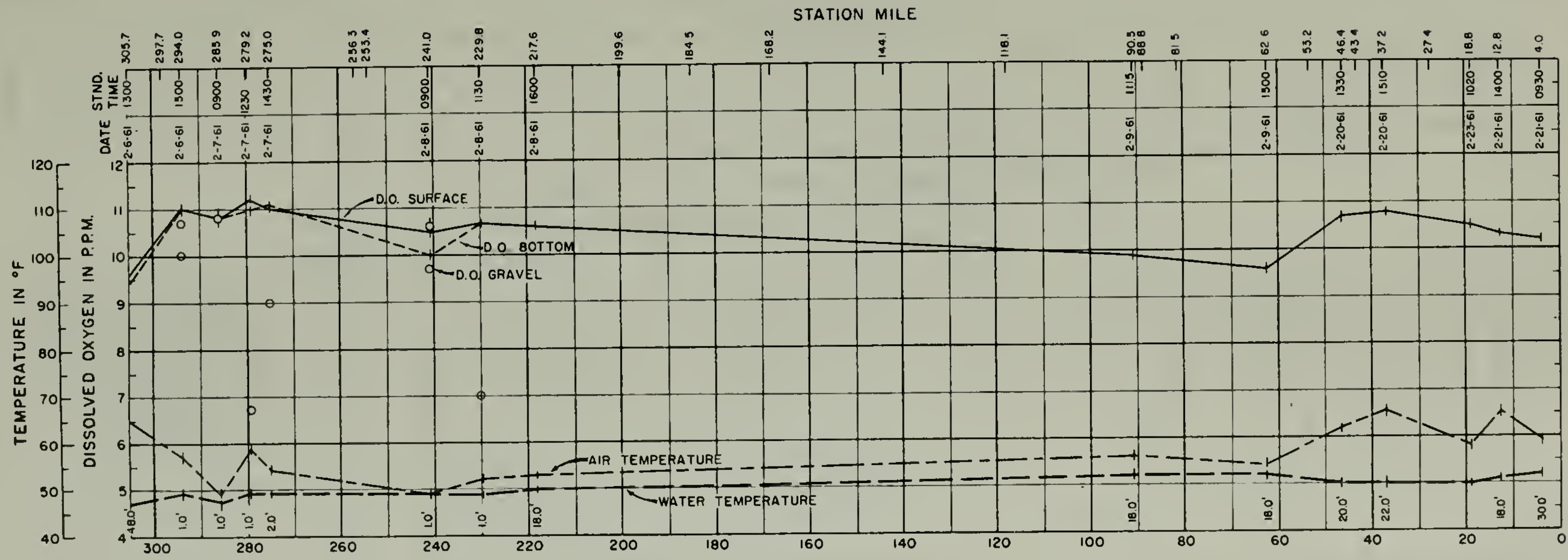


FIGURE 6

SACRAMENTO RIVER WATER POLLUTION SURVEY

BIOLOGICAL SURVEY-PHYSICAL DATA

FEBRUARY 1961



MARCH 1961

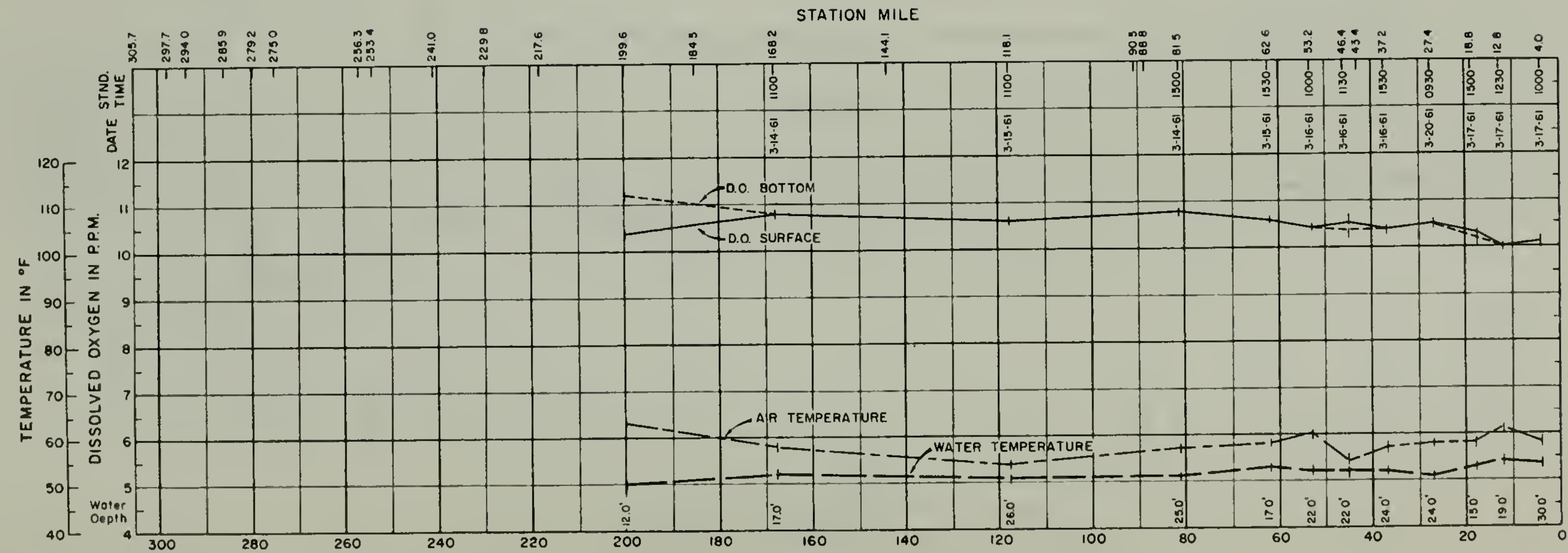


FIGURE 7
SACRAMENTO RIVER WATER POLLUTION SURVEY
BIOLOGICAL SURVEY-PHYSICAL DATA
APRIL 1961

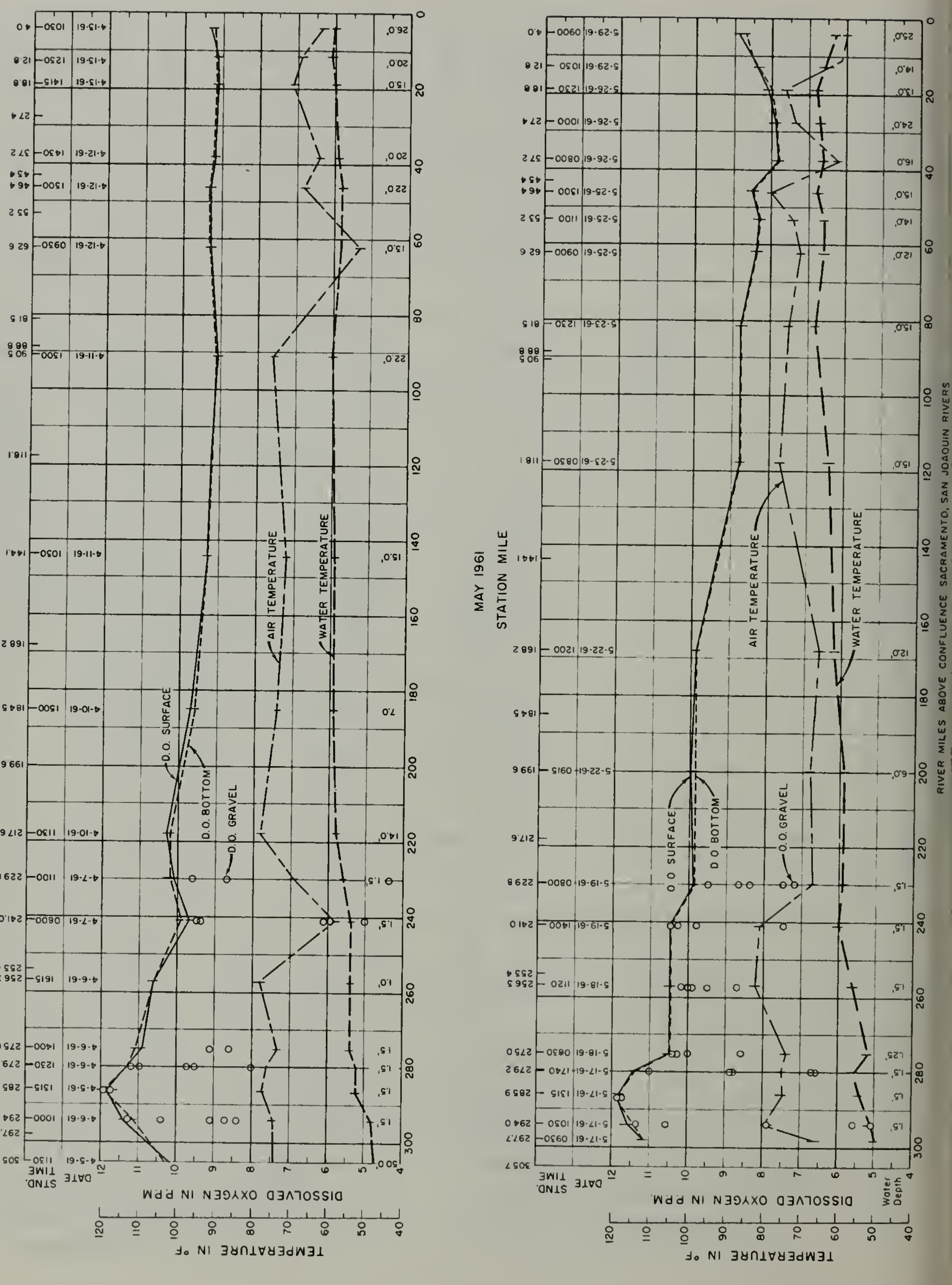


FIGURE 8
SACRAMENTO RIVER WATER POLLUTION SURVEY
BIOLOGICAL SURVEY-PHYSICAL DATA
JUNE 1961

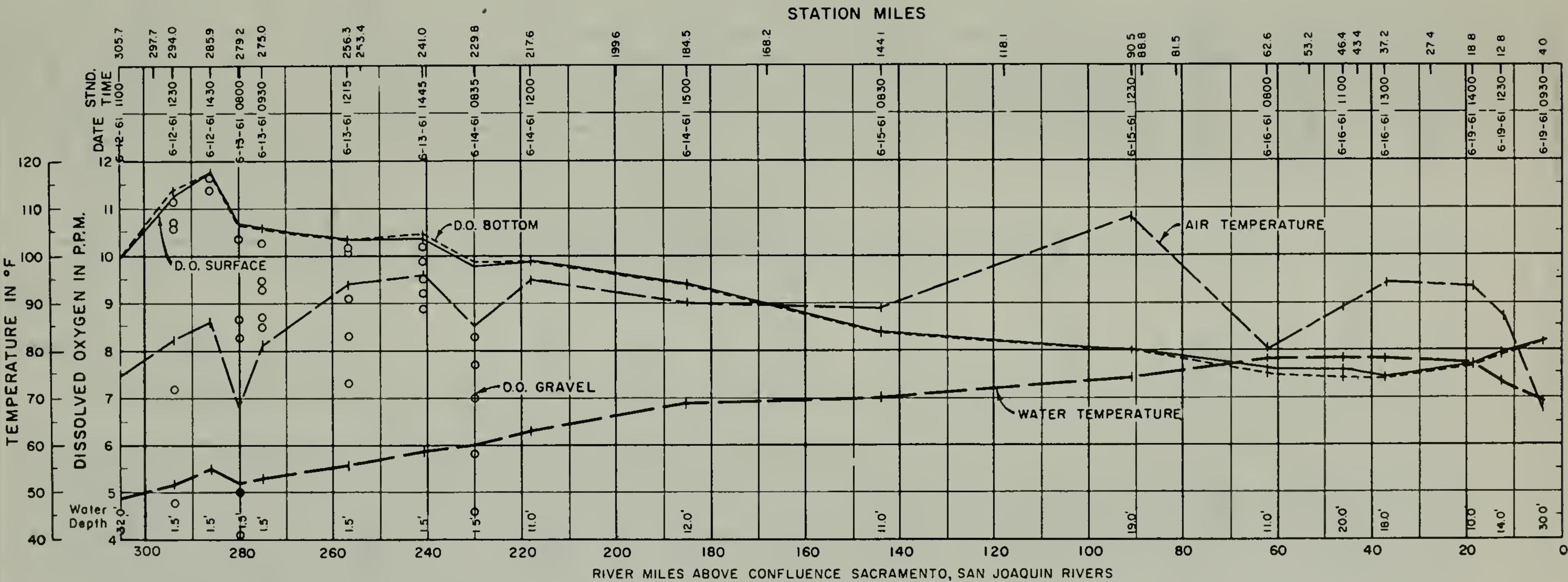
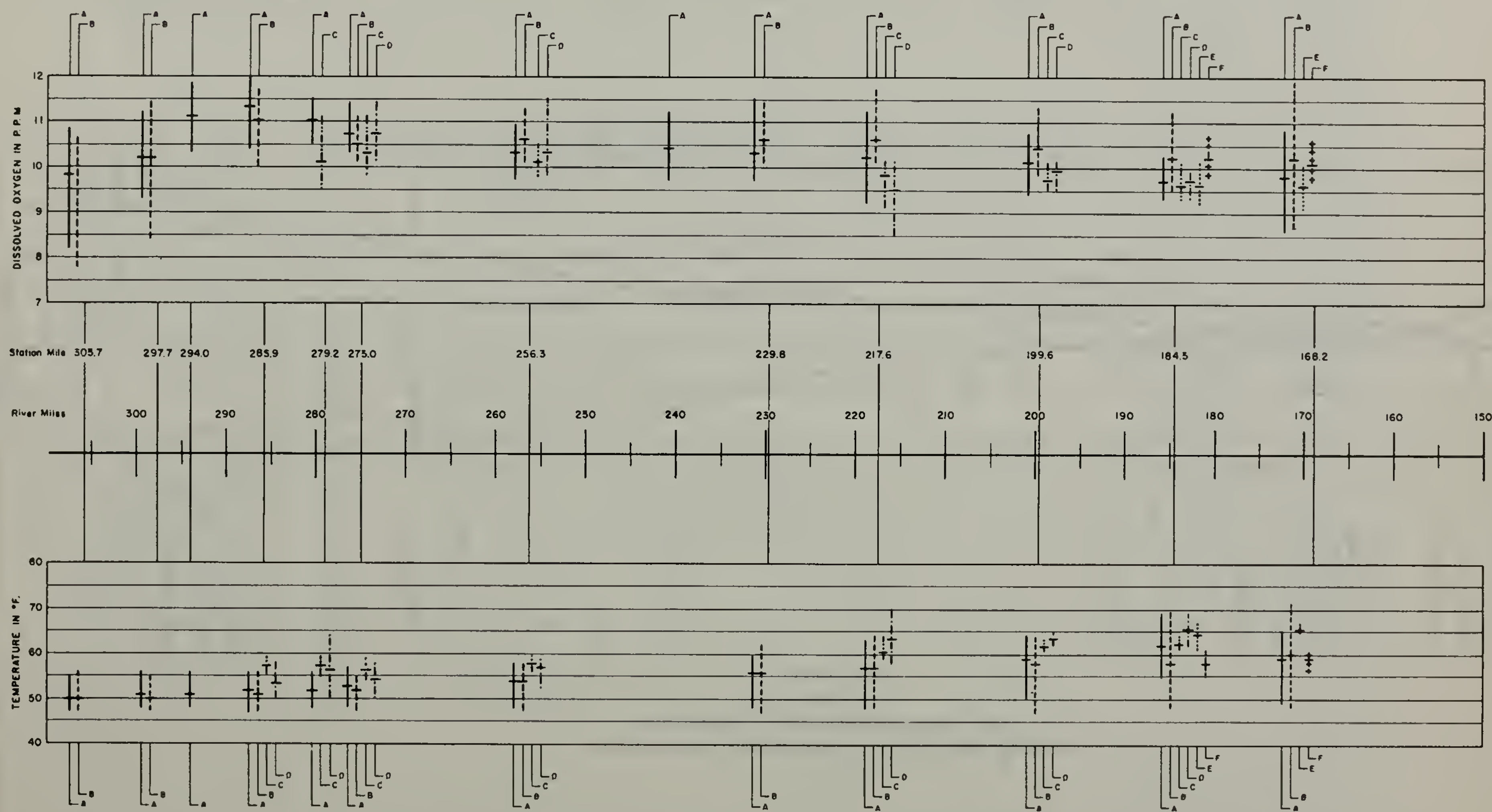


FIGURE 9

SACRAMENTO RIVER WATER POLLUTION SURVEY

DISSOLVED OXYGEN AND WATER TEMPERATURE AT SELECTED STATIONS

River Mile 150 to 305.7



A — BIOLOGICAL SURVEY MONTHLY SAMPLING, APRIL 1960-JUNE 1961 *1

B — MONTHLY SAMPLE APRIL 1960 to JULY 1961 *2

C — INTENSIVE SAMPLING OCTOBER 3 to 7, 1960 *3

Average

D — INTENSIVE SAMPLING JUNE 6 to 10, 1960 *3

E — INTENSIVE SAMPLING SEPT. 12 to 16, 1960 *3

F — INTENSIVE SAMPLING MAY 8 to 12, 1961 *3

Range

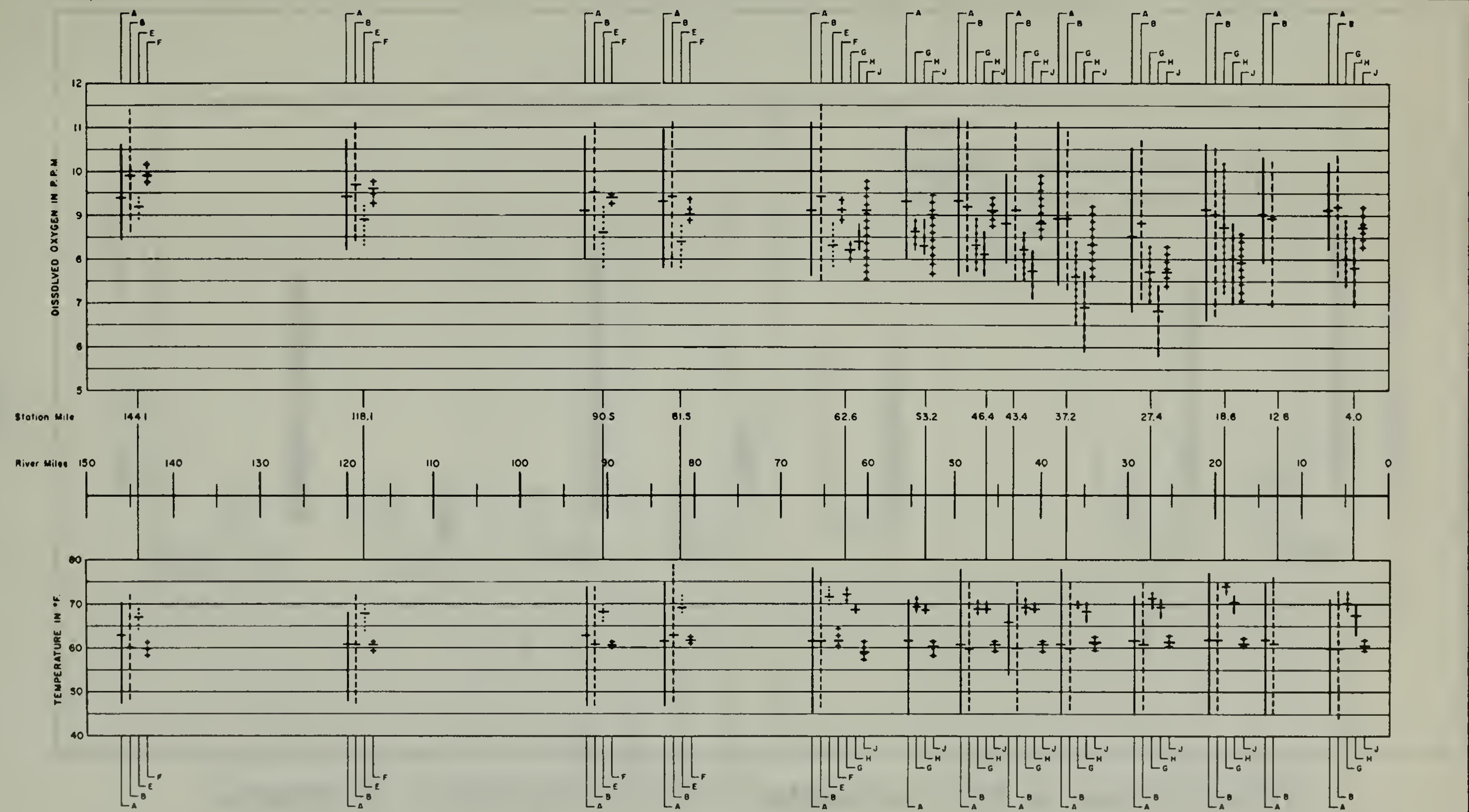
*1 - MONTHLY SAMPLES BIOLOGICAL SURVEY: These samples were taken during the day at biological sampling stations

*2 - MONTHLY SAMPLES: These were daytime samples taken in connection with other phases of the pollution survey. Generally, for any given station, sampling dates did not correspond to those of the biological survey In most cases they were taken at a time other than the biological sampling period

*3 - INTENSIVE SAMPLING: To determine durnal variations, samples were taken at selected stations during a 4-day period at 2 or 3 hour intervals

FIGURE 10

SACRAMENTO RIVER WATER POLLUTION SURVEY
DISSOLVED OXYGEN AND WATER TEMPERATURE AT SELECTED STATIONS
River Mile 0 to 150



Range

A — BIOLOGICAL SURVEY MONTHLY SAMPLING, APRIL 1960-JUNE 1961 *1

B — MONTHLY SAMPLE APRIL 1960 to JULY 1961 *2

C — INTENSIVE SAMPLING SEPT. 12 to 16, 1960 *3

Average

F — INTENSIVE SAMPLING MAY 8 to 12, 1961 *3

G — INTENSIVE SAMPLING JUNE 20 to 24, 1960 *3

H — INTENSIVE SAMPLING AUG. 29 to Sept 2, 1960 *3

J — INTENSIVE SAMPLING OCTOBER 24 to 28, 1960 *3

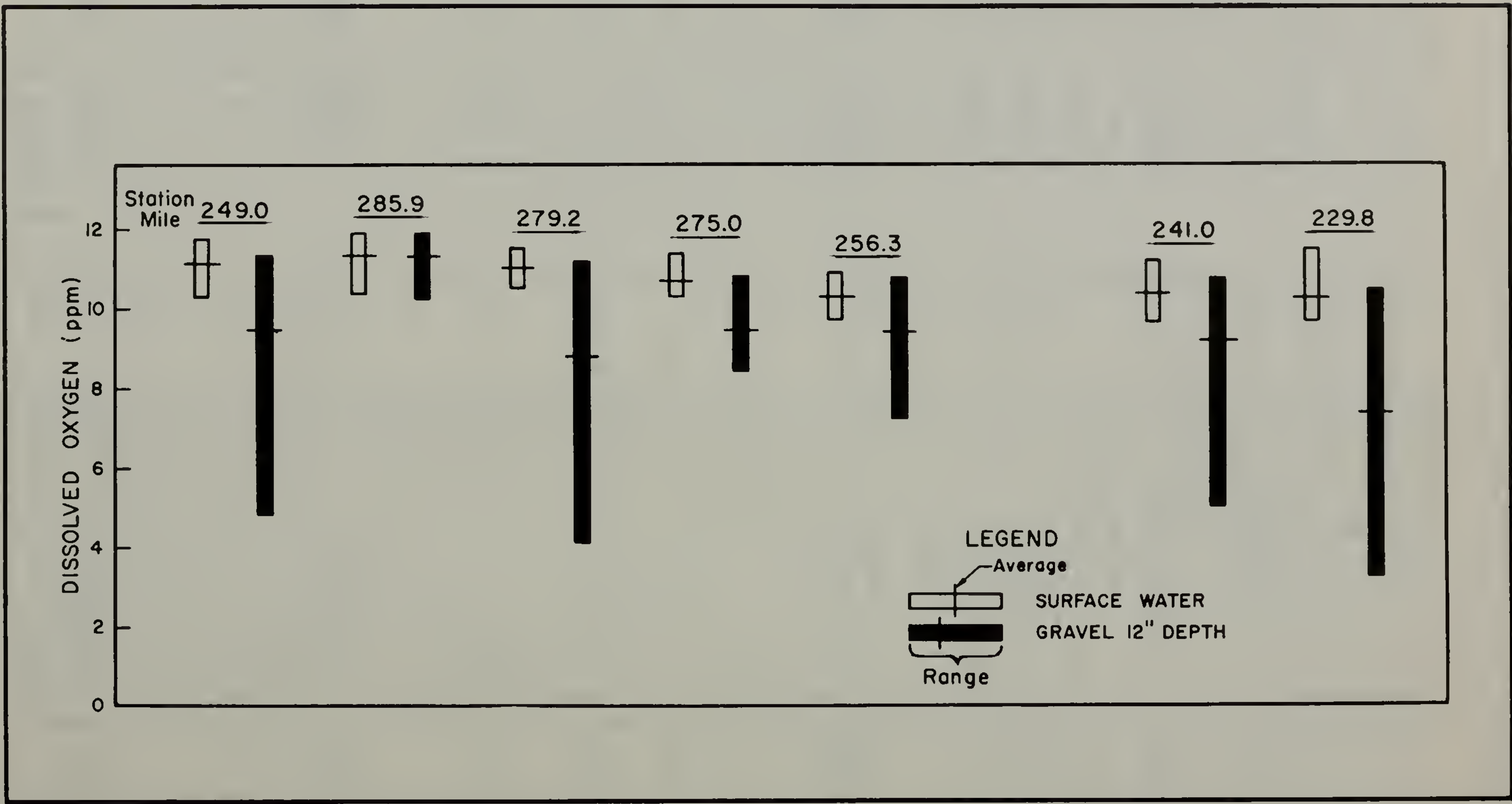
*1 - MONTHLY SAMPLES BIOLOGICAL SURVEY: These samples were taken during the day at biological sampling stations

*2 - MONTHLY SAMPLES These were daytime samples taken in connection with other phases of the pollution survey. Generally, for any given station, sampling dates did not correspond to those of the biological survey. In most cases they were taken at a time other than the biological sampling period

*3 - INTENSIVE SAMPLING To determine diurnal variations, samples were taken at selected stations during a 4-day period at 2 or 3 hour intervals

FIGURE 11

RANGES OF DISSOLVED OXYGEN CONCENTRATIONS IN RIFFLE AREAS



Water Transparency

Water transparency was measured by use of a 20-centimeter Secchi disc. The depth at which the disc disappeared from sight was recorded. Although this reading is subject to a number of errors, it is a useful qualitative indication of water clarity. Figure 12 shows that transparency was reduced from a range of about 80 to 200 inches at Keswick to from 10 to 40 inches at and below Sacramento. Seasonal reductions are due to unregulated storm inflows during the winter and to plankton levels and to waste discharges during the summer. The relationships between transparency, turbidity, and light transmission characteristics are discussed in greater detail in Chapter IV, Appendix B.

Sediments

Bottom particle sizes were determined at all stations. Although there were local differences between closely-spaced sampling points, the averaged data shown in Figures 13 and 14 indicate the general pattern of particle size distributions in the river. Stations at miles 217.6, 168.2, 144.1, 90.5, 81.5, 62.6, 37.2, 18.8, and 12.8 were resampled at varying intervals; seasonal variations at individual stations were about the same as variations between closely-spaced points sampled at one time.

FIGURE 12

SACRAMENTO RIVER WATER POLLUTION SURVEY

SECCHI DISC READINGS - SACRAMENTO RIVER 1960-61

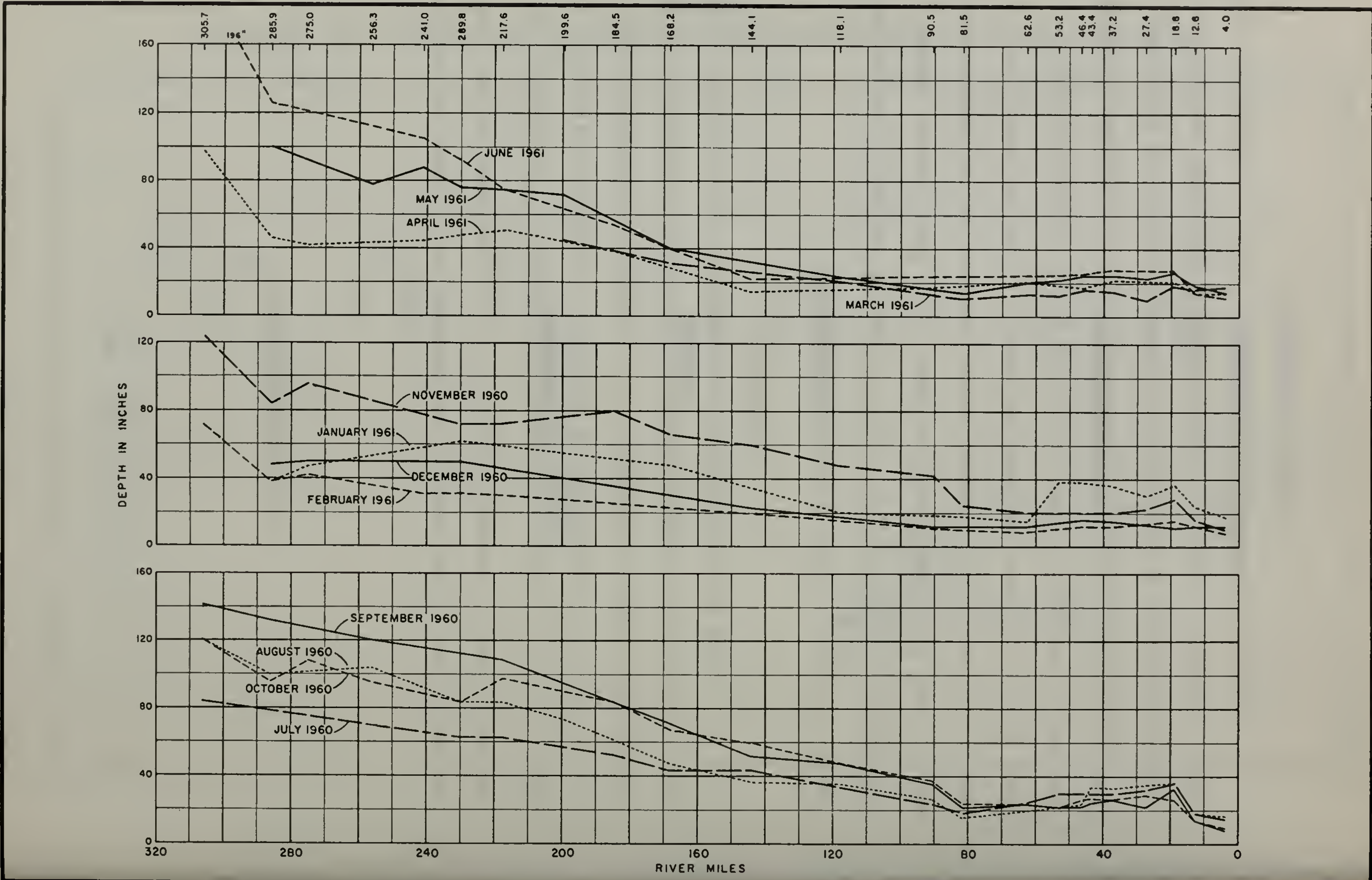


FIGURE 13

SACRAMENTO RIVER WATER POLLUTION SURVEY

GRAVEL SIZE DISTRIBUTION AT SELECTED RIFFLE STATIONS

MILE 297.7 TO MILE 229.8

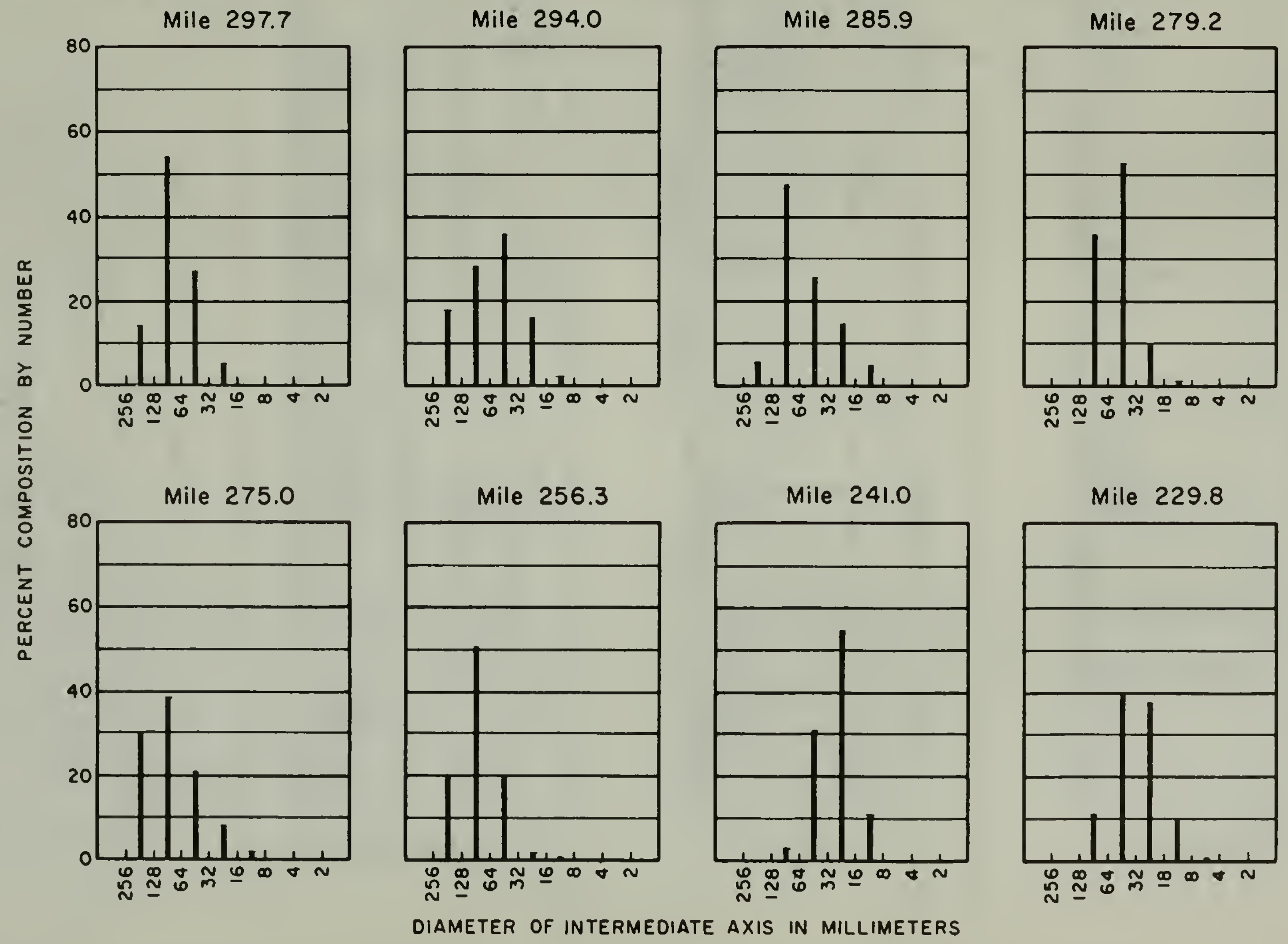
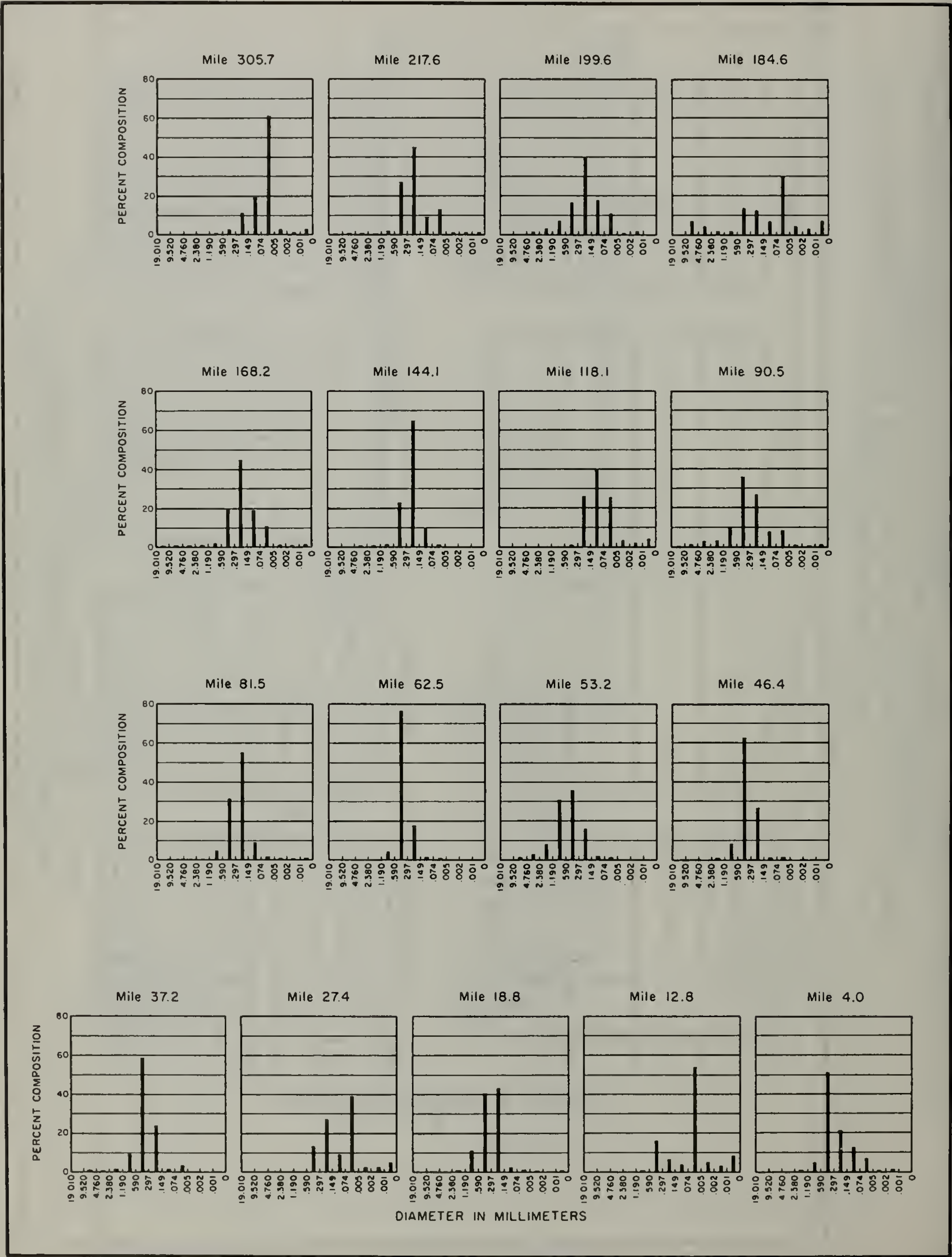


FIGURE 14

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM PARTICLE SIZE DISTRIBUTION AT SELECTED NON-RIFFLE STATIONS



CHAPTER IV. BENTHIC BIOLOGY

Although both plants and animals were collected, emphasis was given to the collection, identification, and enumeration of the bottom fauna.

Results

Aquatic Plants

A list of the incidence of aquatic plants collected during the survey is given in Table 1. With two exceptions, all of these collections were made with a Surber bottom sampler. Two species of pondweed (*Potamogeton pectinatus* and *P. crispus*) were collected in a still pool near the sampling station at mile 295.2, and several specimens from a large growth of *Ranunculus aquatilis* were collected near shore in Keswick Reservoir at mile 305.7

Fragments of *Potamogeton* collected at four of the riffle stations were washed into the sampling net by the current, and were not growing in the river at the sampling location. Similarly, *Lemna* found at two stations were also washed into the collecting net.

The moss, *Fissidens*, was present throughout the year at all of the riffles which were sampled for bottom organisms. These plants became more or less dormant during the winter (December-February), but were extremely abundant during the summer and early fall months.

Twenty-seven genera of algae were identified from the bottom samples. Representatives of green, blue-green, red, and yellow algae, and diatoms were included. Algae was identified to genus when it was encountered in a sample. No attempt was made to determine the volumes of algae which, in most of the samples, was less than 0.1 cc.

Table 1

SACRAMENTO RIVER WATER POLLUTION SURVEY
AQUATIC PLANTS

Aquatic Plants	Station Mile												
	305.7	297.7	295.2	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	118.1	18.8
ALGAE[1]													
Grass-Green Algaes (Chlorophyta)													
Cladophoraceae													
Cladophora sp.	x	x		x		x	x	x	x	x	x		
Chloroccaceae													
Chlorococcum sp.		x											
Chaetophoraceae													
Stigeoclonium sp.		x		x					x				
Microthamnion sp.			x							x	x		
Desmidiaceae													
Desmidium sp.							x						
Dichotomosiphonaceae													
Dichotomosiphon sp.										x			
Hydrodictyaceae													
Pediastrum sp.								x					
Microsporaceae													
Microspora sp.										x			
Palmellaceae													
Gloecystis sp.								x					
Tetrasporaceae													
Tetraspora sp.		x		x									
Ulothrichaceae													
Ulothrix sp.	x	x	x	x	x		x	x		x			
Zygnemataceae													
Spirogyra sp.			x	x	x	x	x	x		x	x		
Blue-Green Algaes (Cyanophyta)													
Chroococcaceae													
Coccochloris sp.					x								
Nostocaceae													
Nostoc sp.		x			x			x	x		x		
Anabaena sp.					x								
Scytonemataceae													
Scytonema sp.										x	x		
Tolypothrix sp.		x		x	x	x	x	x	x	x	x		
Oscillatoriaceae													
Oscillatoria sp.		x		x	x	x	x			x	x		
Lyngbya sp.				x	x	x				x			x
Spirulina sp.						x							
Red Algae (Rhodophyta)													
Batrachospermaceae													
Batrachospermum sp.		x		x		x				x			
Chautransiaceae													
Audouinella sp.	x	x		x	x	x	x	x		x	x	x	

Table 1

SACRAMENTO RIVER WATER POLLUTION SURVEY
AQUATIC PLANTS
(continued)

Aquatic Plants	Station Mile												
	305.7	297.7	295.2	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	118.1	18.8
ALGAE (continued)													
Yellow-Green Algae (Chrysophyta)													
Vaucheriaceae													
Vaucheria sp.	x	x		x	x		x	x	x		x		
Diatoms (Chrysophyta)													
Achnanthaceae													
Cocconeis sp.										x			
Coscinodiscaceae													
Stephanodiscus sp.											x		
Melosira sp.	x	x								x			
Naviculaceae													
Navicula sp.										x	x		
Gomphonemaceae													
Gomphonema sp.										x			
MOSSES[1/] (Bryophyta)													
Eurhynchium sp.				x									
Fissidens sp.	x	x		x	x	x	x	x	x	x	x		
Fontinalis sp.				x									
VASCULAR PLANTS[2/]													
Lemnaceae													
Lemna sp.[3/]					x		x						
Potamogetonaceae													
Potamogeton sp.		x	x		x			x			x		
Ranunculaceae													
Ranunculus sp.	x												

1/ Taxonomy from Ward and Whipple (1959).
2/ Taxonomy from Muenscher (1944).
3/ Floating plants, but not in same category as phytoplankton.

Very few aquatic plants were found at the sampling stations below mile 229.8. One species of red algae was found at station 118.1, and a blue-green alga was collected at mile 18.8. Otherwise, no identifiable plant material was collected.

In the lower-most portions of the river, emergent plants such as cattail (Typha) and tule (Scirpus) are present in shallow water areas along the river banks. These plants were not included in Table 1.

Bottom Fauna

Results of bottom samples taken to determine the benthic fauna of the Sacramento River are given in Tables 2 through 16. These tables present the numbers of organisms collected per square foot at the various stations during each month of the survey. The volumes of organisms are not indicated; however, this information is available at the Department of Fish and Game Field Station in Sacramento.

An examination of Tables 2 through 16 indicates the large variety of aquatic organisms that exists in the Sacramento River. Representatives of ten phyla, ranging from the sponges to the chordates were collected. At least 164 separate species of invertebrates were represented in the collections in addition to one species of lamprey. It must be pointed out that a large number of individual specimens were not identified to species. Some organisms were not classified below order due to lack of time, facilities, and adequate keys.

Numbers and Volume at Selected Stations

The Sacramento River between Shasta Dam and the mouth was divided into four major environments. These are: (1) the upper river, which consists of alternate pools and riffles (approximately mile 297 to mile 229); (2) the upper-middle river, which contains a few riffles but mostly

TABLE 2

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

APRIL 1960

CLASSIFICATION	RIVER MILES																													
	3 5.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	227.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/01	88.2	81.5	80.8 L/01	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Porifera																															
Spongillidae																															
Spongilla fragilis																											X				
Coelenterata																															
Hydridae																															
Hydria sp.								.3																							
Nemathelminthes																															
Nematoda			4					.3		.3																					
Annelida																															
Oligocheata			2092	1	.3						.3	4		54	66.1			7.2			1.2		15	2						6	
Arthropoda																															
Crustacea																															
Malacostraca																															
Aphipoda																															
Corophium spinicorne																														3	
Insecta																															
Plecoptera																															
Pteronarcidae								.7																							
Perlodidae																															
Isogenus sp.					.3		.7																								
Isoperla sp.					.7					2.3	.3																				
Odonata																															
Agrionidae																															
Argia sp.								.3																							
Gomphidae																															
Gomphus olivaceous																					.6										
Ephemeroptera																															
Baetidae																															
Baetis sp.				3	11		13.3	.3		17.7	12.7																				
Pseudocloeon sp.					.3		4.7	10		46.7	37																				
Ephemerellidae																															
Ephemerella inermis							.3																								
Tricorythidae																															
Tricorythodes fallax								.3																							
Hemiptera																															
Naucoridae																															
Ambrysus mormon							.3	.3																							
Trichoptera																															
Rhyacophilidae																															
Rhyacophila sp.							7.3																								
Agapetus sp.				22.4	37.9			1		4.7	3																				
Hydropsychidae																															
Hydropsyche sp.				1	1.3		32.3	3.3		4	4.3																				
Hydroptilidae																															
Ochrotrichia sp.			16	.3																											
Lepidostomatidae																															
Lepidostoma sp.				.7	.3																										
Coleoptera																															
Dytiscidae				.7																											
Oseozebudae																															
Psephenus sp.							.3	.3																							
Elmidae																															
Narpus sp.								.3																							
Hymenoptera																															
Figitidae							.3																								
Diptera																															
Tipulidae																															
Antocha sp.				7.9	7		8.3				1																				
Simuliidae																															
Simulium sp.										.3	36.3									1.2											
Tendipedidae				204.3			8.3	83.8			29	64		1.8	10.7	5.4				3.6	6										
Diamesinae					3.3																										
Diamesa spp.				.7						21.7																					
Pelopiinae			12																												
Tendipedinae			20															5.4													
Tendipes spp.					.3																										
Calopsectra spp.				.3																											
Hydrobaeninae					56.7																						.5				
Metriocnemus sp.										.3																					
Cardiocladius sp.										.3																					
Cricotopus sp.					.7																										
Spaniotoma sp.				1						2																					
Heleidae				.3																											
Culicoides sp.															1.8																
Sphaeromiae sp.																											.5				
Empididae																															
Hemerdromia sp.							.3																								
Anthomyiidae																															
Limnophora aquifrons																															
Acari																															
Hydracarina			8	3.3	2.3		.3	1		1.3	.3																				

Samples taken - no bottom organisms - mile 199.6, 118.1, 43.4, 18.8.

TABLE 2 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

APRIL 1960

CLASSIFICATION	RIVER MILES																													
	305 7	297 7	295 5	294 0	285 9	279 [illegible]	[illegible]	[illegible] 3	253 4	241 0	[illegible] 8	[illegible] 6	199 6	84 5	168 2	144 1	118 1	90 5	902 R/O	88 2	81 5	808 L O	62 6	53 2	46 4	43 4	37 2	27 4	18 8	2 8	4 0
Mollusca																															
Sphaeriidae																															
Pisidium sp.			312																												
Corbiculidae																															
Corbicula fluminea																				.6	1.8		18	4	7.5		6	9		1.5	

TABLE 3

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

MAY 1960

CLASSIFICATION	RIVER MILES																														
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/O	88.2	81.5	80.8 L/O	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Porifera																															
Spongillidae																										X					
Spongilla fragilis																															
Nemathelminthes												1.5														75					
Nematoda																															
Annelida																															
Oligochaeta	540		205.5	.3			1	.7			1	123	1.5	36	1			7.5				10.5	2.5	3.0	.8	2.2		50.5		87	1.5
Aeolosomatidae																															
Naididae																												5.5			
Chaetogaster sp.																		3													
Paranais sp.														1.5																	
Tubificidae																															
Branchiura sowerbyi																		.5													
Nereidae																											1.5	1.0			
Neanthes limnicola																															
Tardigrada																										3.8					
Arthropoda																															
Crustacea																															
Malacostraca																															
Amphipoda																															
Corophium spinicorne																	.5				23.5			.5						6.8	130.5
Insecta																															
Plecoptera																															
Perlodidae																															
Isogenus sp.													1																		
Isoperla sp.								1			.3																				
Ephemeroptera																															
Baetidae																															
Baetis sp.				4	5		6.3	10.7		.7																					
Pseudocloeon sp.							7	1		.7	10.7												.5								
Leptophlebiidae																															
Trichoptera																															
Rhyacophilidae										.3																					
Rhyacophila sp.					1.3																										
Agapetus sp.				1.7				17.3																			.8				
Hydropsychidae													1																		
Hydroptilidae																															
Ochrotrichia sp.				.3																											
Macronemum sp.																															
Hydropsyche sp.				.7			.7	35.7			2.3																				
Leptoceridae																															
Diptera																															
Tipulidae																															
Antocha sp.								6.3																							
Simuliidae																															
Eusimulium sp.											.7																.8		1		
Tendipedidae				5.3	32.3		32	6.7	3			10.5	.5	16.5	5		.5	3.5					.5	4							
Diamesinae																3.5															
Diamesa spp.											6																				
Pelopiinae	4																														
Procladius sp.	4		3																											3.8	
Tendipedinae																		.5						1				1.5			
Tendipes spp.	8		3	76.8																						5.3					
Tanytarsus sp.																															
Cryptochironomus spp.																	4.5														
Hydrobaeninae																		1.5			1.5		1		1.5						
Spaniotoma sp.										.7																					
Heleidae																															
Mollusca																															
Sphaeriidae																															
Pisidium sp.			10.5																												
Corbiculidae																															
Corbicula fluminea																		2		0.5	6		5.5	3.5	18	2.2	20	3.5			3
Vertebrata																															
Petromyzontidae																															
Lampetra sp.												1.5		14																	

TABLE 4

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

JUNE 1960

CLASSIFICATION	RIVER MILES 305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	240	229.8	2?6	396	845	168.2	144.1
Nemathelminthes																
Nematoda							1.3									
Annelida																
Oligochaeta	70		13.5		5			.3	2	21.7			21	25.5	1	
Tubificidae																
Branchiura sowerbyi																
Telmatodrilus sp.		.3														
Nereidae																
Neanthes limnicola																
Arthropoda																
Crustacea																
Malacostraca																
Amphipoda																
Corophium spinicorne																
Insecta																
Plecoptera																
Pteronarcidae																
Pteronarcys californica								.3								
Perlodidae																
Isoperla trictura								.7								
Odonata																
Gomphidae													1.5			
Gomphus olivaceous														1.5		
Ephemeroptera																
Baetidae																
Baetis sp.		4		4	10		2.7	.7	1		.7					
Pseudocloeon sp.		.7		.3	1.3		7	60.7	2.7		32.3					
Trichoptera																
Rhyacophilidae							.3		.7							
Agapetus sp.				22.3	9.7		1.3	3.7								
Psychomyiidae																
Psychomyia sp.											.3					
Hydropsychidae																
Hydropsyche sp.					3			24			10.3					
Hydroptilidae																
Ochrotrichia sp.		1														
Leptoceridae																
Lepidostomatidae																
Lepidostoma sp.					.7											
Coleoptera																
Dytiscidae																
Bidessus sp.									.3							
Psephenidae																
Psephenus sp.								.3								
Diptera																
Tipulidae										.7						
Antocha sp.				.3	1.3											
Psychodidae																
Psychoda severini											.3					
Simulidae																
Simulium sp.							1				29.7					
Tendipedidae		100	4.5	48.7	170.3		17.3	11.3	5.3	64.5				15	13.5	3
Diamesa											1					
Tendipedinae																
Tendipes tentans													217.5			
Tendipes spp.																
Calopsectra spp.											.3					
Polypedilum sp.																
Pentapedilum spp.																
Cryptochironomus spp.											.7	39				
Hydrobaeninae																
Cricotopus sp.											1					
Heleidae																
Culicoides sp.														1.5		
Ephydridae																
Acari																
Hydracarina					1.7											
Halacaridae													1.5			
Mollusca																
Physidae																
Physa sp.	4	.7														
Planorbidae																
Gyraulus sp.	22															
Sphaeriidae																
Pisidium sp.	76															
Corbiculidae																
Corbicula fluminea																
Vertebrata																
Petromyzontidae																
Lampetra sp.										5.3		1.5	1.5		1	1

CLASSIFICATION	RIVER MILES 18	90.5	90.2 R/O	88.2	81.5	80.8 L/O	62.6	53.2	46.4	43.4	37.2	27.4	18.8	2.8	4.0
Nemathelminthes															
Nematoda															
Annelida															
Oligochaeta		19.5	61.5	5.2	17.3			2.3	9		27	58.5		39	39
Tubificidae															
Branchiura sowerbyi			7.5												
Telmatodrilus sp.															
Nereidae															
Neanthes limnicola					.8						2.3	3	.5		
Arthropoda															
Crustacea															
Malacostraca															
Amphipoda															
Corophium spinicorne				25.5	147								1	1.5	1.5
Insecta															
Plecoptera															
Pteronarcidae															
Pteronarcys californica															
Perlodidae															
Isoperla trictura															
Odonata															
Gomphidae															
Gomphus olivaceous															
Ephemeroptera															
Baetidae															
Baetis sp.															
Pseudocloeon sp.															
Trichoptera															
Rhyacophilidae															
Agapetus sp.															
Psychomyiidae															
Psychomyia sp.															
Hydropsychidae															
Hydropsyche sp.															
Hydroptilidae															
Ochrotrichia sp.															
Leptoceridae															
Lepidostomatidae															
Lepidostoma sp.															
Coleoptera															
Dytiscidae															
Bidessus sp.															
Psephenidae															
Psephenus sp.															
Diptera															
Tipulidae															
Antocha sp.															
Psychodidae															
Psychoda severini															
Simulidae															
Simulium sp.															
Tendipedidae					9						9	8.3	1		
Diamesa															
Tendipedinae				3.8											
Tendipes tentans			21						15						
Tendipes spp.		16.5	10.5		3							7.5		.8	
Calopsectra spp.															
Polypedilum sp.														.8	
Pentapedilum spp.		2.3													
Cryptochironomus spp.								3	10.5			.8		3	
Hydrobaeninae															
Cricotopus sp.															
Heleidae							3								
Culicoides sp.															
Ephydridae															
Acari															
Hydracarina															
Halacaridae															
Mollusca															
Physidae															
Physa sp.															
Planorbidae															
Gyraulus sp.															
Sphaeriidae															
Pisidium sp.															
Corbiculidae															
Corbicula fluminea					.8		21	5.3	3		5.3	1.5	1.5		
Vertebrata															
Petromyzontidae															
Lampetra sp.				1.5	.8										

TABLE 5

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

JULY 1960

CLASSIFICATION	RIVER MILES																														
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2	144.1	[illegible]8	90.5	90.2 R/D	88.2	81.5	80.8 L/D	62.6	53.2	46.4	43.4	37.2	27.4	18.8	2.8	4.0
Nemathelminthes																															
Nematoda		1.7			.3					1.5																					
Annelida																															
Oligochaeta	244.5	.3	46.5	.7	.3					1.5			4.5	8.3	3.8			12	15	2.3		27		1.5	4.5			24		78	3
Tubificidae																															
Nereidae																															
Neanthes limnicola																										1.5		3	2.3		
Arthropoda																															
Crustacea																															
Malacostraca																															
Amphipoda																															
Corophium spinicorne																													3.8		258
Insecta																															
Odonata																															
Ephemeroptera																															
Baetidae																															
Baetis sp.		13.7		10	6.3		3.3	.3	23.3		.3		.8																		
Pseudocloeon sp.		5.3			13		21	1.3	48.3		8.3																				
Tricorythidae																															
Tricorythodes fallax																															
Trichoptera																															
Rhyacophilidae																															
Rhyacophila sp.								.7	.3																						
Agapetus sp.		.7			1.7		.3																								
Hydropsychidae																															
Hydropsyche sp.				.7			.7	1.7	5.3		13.7																				
Hydroptilidae																															
Agraylea sp.		18.7																													
Diptera																															
Tanyderidae											.3					1	1.5														
Tipulidae																															
Antocha sp.					4.7			.3																							
Helius sp.					.3																										
Simuliidae					2			.3	70.4		14.3			1.5																	
Simulium sp.							1.7																								
Tendipedidae		187.3		18.7	9		37	.3	10.3		2.3	24			5.3	.5								3	9.8			3			
Diamesa spp.							1																								
Prodiamesa sp.										1.5																					
Pelopiinae																															
Procladius sp.	10.5		6							1.5																1.5					
Tendipedinae																															
Tendipes tentans			21										73.5																		
Tendipes spp.			69							105				10.5				18	1.5										.8		
Calopsectra spp.					.3																										
Tanytarsus sp.																	.5														
Polypedilum sp.			1.5							4.5			.8																		
Cryptochironomus spp.			7.5															2.3					3				8.3				
Cricotopus sp.	3																														
Anthomyiidae																															
Limnophora Aruifrons		.3			.3																										
Ephydridae																															
Hydrellia sp.			1.5																												
Mollusca																															
Physidae																															
Physa sp.		.3		.3															1.5												
Planorbidae																															
Gyraulus sp.	1.5																														
Sphaeriidae																				.8											
Pisidium sp.	25.5																														
Corbiculidae																															
Corbicula fluminea																		.8	3		1	1.5	1.5	17.3	5.3	7.5		10.5	3		
Vertebrata																															
Petromyzontidae																															
Lampetra sp.													.8		1.5								.8								

TABLE 6

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

AUGUST 1960

CLASSIFICATION	RIVER MILES 305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2	144
Hemathelminthes																
Nematoda			.3	.3	.3											
Annelida																
Oligochaeta			12	.3	.7				1	3			13.5	28.5	7.5	
Tubificidae	229.5															
Nereidae																
Neanthes limnicola																
Arthropoda																
Crustacea																
Clodocera																
Daphnidae																
Daphnia Laevis				.7												
Copepoda																
Malacostraca																
Amphipoda																
Corophium spinicorne																
Mysidacea																
Peracarida																
Neomysis mercedis																
Insecta																
Plecoptera																
Nemouridae																
Nemoura columbiana								.3								
Perlodidae																
Isogenus frontalis								.7								
Isoperla sp.								.3								
Odonata																
Gomphidae																
Erpetogomphus sp.								.3								
Ephemeroptera																
Baetidae																
Baetis sp.		2.3		1.3	3.7		11.7	26.7	5		5.7					
Pseudocloeon sp.		7.7		10	71.7		33	3.3	66.3		21.7					
Heptageniidae																
Heptagenia sp.																
Tricorythidae																
Tricorythodes fallax									.3							
Trichoptera																
Rhyacophilidae																
Agapetus sp.				4	4		5.3	6			6.7					
Hydropsychidae																
Hydropsyche sp.				1	2.3		17	74	11.3		42.3					
Hydroptilidae																
Ochrotrichia sp.		54.7		44	9		2.7	.3	3.3							
Leptoceridae	3															
Leptocella sp.																
Lepidostomatidae																
Lepidostoma sp.		.7			.3		.3		.7							
Coleoptera																
Dytiscidae																
Agabus sp.		.3														
Oreodytes sp.		1.3			.3											
Elmidae																
Stenelmis sp.											.3					
Diptera																
Tipulidae																
Antocha sp.					20.3		.7	.7	.7		.7					
Simuliidae							13	53.3								
Simulium sp.				.7	1.3				27		70.3					
Tendipedidae		96		53.3	68.7		51.3	14.3	40.3	69	5.3		18	7.5		3
Pelopiinae																
Procladius sp.	1.5		9													
Tendipedinae																
Tendipes plumosus										9						
Tendipes spp.	3		61.5										15			
Calopsectra spp.								.7								
Tanytarsus (endochironomus) sp.																
Polypedilum sp.																
Pentapedilum spp.																
Cryptochironomus spp.			37.5								.3	9.8			9.8	
Hydrobaeninae																
Cricotopus sp.	1.5										.7					
Spaniotoma (eukiefferiella) sp.					4.7						.7					
Haleidae																
Culicoides sp.									.3							
Acari																
Hydracarina				.7	.3		.7		3.7							
Mollusca																
Physidae																
Physa sp.	3															
Planorbidae																

CLASSIFICATION	RIVER MILES 118	90.5	90.2 R/O	88.2	81.5	80.8 L/O	62.6	53.2	46.4	43.4	37.2	27.4	18.8	2.8	4.0
Hemathelminthes															
Nematoda		2.3			.8										
Annelida															
Oligochaeta		12	8.3			6	1.5	21	7.5	13.5	15	148.5	18	91.5	
Tubificidae															
Nereidae															
Neanthes limnicola										.8	1.5		1.5		
Arthropoda															
Crustacea															
Clodocera															
Daphnidae															
Daphnia Laevis															
Copepoda															
Malacostraca															
Amphipoda															
Corophium spinicorne					76.5							1.5		24	234
Mysidacea															
Peracarida															
Neomysis mercedis															1.5
Insecta															
Plecoptera															
Nemouridae															
Nemoura columbiana															
Perlodidae															
Isogenus frontalis															
Isoperla sp.															
Odonata															
Gomphidae															
Erpetogomphus sp.															
Ephemeroptera															
Baetidae															
Baetis sp.															
Pseudocloeon sp.															
Heptageniidae															
Heptagenia sp.	.8														
Tricorythidae															
Tricorythodes fallax															
Trichoptera															
Rhyacophilidae															
Agapetus sp.										.8					
Hydropsychidae															
Hydropsyche sp.															
Hydroptilidae															
Ochrotrichia sp.															
Leptoceridae															
Leptocella sp.															
Lepidostomatidae															
Lepidostoma sp.															
Coleoptera															
Dytiscidae															
Agabus sp.															
Oreodytes sp.															
Elmidae															
Stenelmis sp.															
Diptera															
Tipulidae															
Antocha sp.															
Simuliidae															
Simulium sp.															
Tendipedidae				6		1.5				11.3					
Pelopiinae															
Procladius sp.															
Tendipedinae															
Tendipes plumosus															
Tendipes spp.		16.5					1.5			5.3			1.5		
Calopsectra spp.															
Tanytarsus (endochironomus) sp.		.8													
Polypedilum sp.							1.5	.8					.8		
Pentapedilum spp.		.8								6		1.5			
Cryptochironomus spp.								7.5	2.3		6	19.5	7.5	13.5	
Hydrobaeninae															
Cricotopus sp.															
Spaniotoma (eukiefferiella) sp.															
Haleidae															
Culicoides sp.															
Acari															
Hydracarina															
Mollusca															
Physidae															
Physa sp.															
Planorbidae															

TABLE 6 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per squore foot

AUGUST 1960

CLASSIFICATION	RIVER MILES															
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	276	199.6	84[illegible]	68.2	44
Menetus sp.	7.5															
Sphaeriidae																
Pisidium sp.	70.5															
Corbiculidae																
Corbicula fluminea																

CLASSIFICATION	RIVER MILES														
	8	90.5	90.2 RO	88.2	81.5	80.8 LO	62.6	51.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Menetus sp.															
Sphaeriidae															
Pisidium sp.															
Corbiculidae															
Corbicula fluminea		.8		1.5	.8		1.5	33	3		3	1.5	6	3	

TABLE 7

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

SEPTEMBER 1960

CLASSIFICATION	RIVER MILES 305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	240	229.8	[illegible]	[illegible]	[illegible]	[illegible]	44
Porifera																
Spongillidae																
Spongilla fragilis																
Coelenterata																
Hydridae																
Hydra sp.			3													
Platyhelminthes																
Planariidae																
Dugesia sp.					1.7											
Nemathelminthes																
Nematoda	3		4.5		1			1								
Annelida																
Oligochaeta	25.5	3	22.5		20.7		2	.7	1.3		.7	9	7.5	45	63	
Naididae																
Chaetogaster sp.								.3								
Tubificidae																
Nereidae																
Neanthes limnicola																
Arthropoda																
Crustacea																
Malacostraca																
Amphipoda																
Corophium spinicorne																
Insecta																
Plecoptera																
Nemouridae																
Nemoura columbiana							.3									
Perlodidae																
Isogenus frontalis								.7			1.3					
Odonata																
Agrionidae																
Argia sedula									.3							
Argia sp.					.3											
Gomphidae																
Hagenius sp.															1.5	
Ephemeroptera																
Baetidae																
Baetis sp.		.7		4.7	1.7		41.7	21.7	4		19.3					
Pseudocloeon sp.					28.3		26.3	5.3	78.3		15					
Trichoptera																
Rhyacophilidae																
Agapetus sp.		2.7		15.3	49.3		52	30	1.7		7					
Psychomyiidae																
Polycentropus sp.							1		.3							
Psychomyia sp.									2.2							
Hydropsychidae																
Hydropsyche sp.					24		180.3	281.3	45.7		173.7			1.5		
Hydropilidae																
Ochrotrichia sp.		27.7		.7	3		3		4.7							
Lepidostomatidae																
Lepidostoma sp.		6.3			1.7		.3	.3	5							
Brachycentridae									.3							
Coleoptera																
Dytiscidae																
Oreodytes sp.		4.7							.7							
Dryopidae																
Helichus sp.								.3								
Elmidae																
Dubiraphia sp.													1.5			
Diptera																
Tanyderidae											.3					
Tipulidae																
Antocha sp.				.3	117.7		8.7	4.3	9.7		2.3					
Blephariceridae											.3					
Simuliidae												1.5		1.5		
Simulium arcticum					.7						65.7					
Simulium sp.		.3					11	18.3	1							
Tendipedidae	1.5	107	3	15.3	77.7		156	11.7			6.7					3
Diamesa spp.		1.3														
Pelopiinae																
Pentaneura spp.								.3	.7							
Procladius sp.										1.5						
Tendipedinae			4.5													
Tendipes plumosus			40.5													
Tendipes spp.										19.5		5.3	13.5			
Calopsectera								15.3	37.3		1.3					
Polypedilum sp.												17.3	4.5	3		
Pentapedilum spp.																
Cryptochironomus spp.												1.5	10.5	7.5	10.5	24

CLASSIFICATION	RIVER MILES 8	90.5	90.2 R/D	88.2	8.5	80.8 L	62.6	53.2	46.4	43.4	37.2	27.4	18.8	2.8	4.0
Porifera															
Spongillidae															
Spongilla fragilis									X	X					
Coelenterata															
Hydridae															
Hydra sp.															
Platyhelminthes															
Planariidae															
Dugesia sp.															
Nemathelminthes															
Nematoda															
Annelida															
Oligochaeta	4.5	34.5	4.5			16.5	6	9	10.5	45	15	163.5	18	111	
Naididae															
Chaetogaster sp.													1.5		
Tubificidae															
Nereidae															
Neanthes limnicola										1.5	1.5		1.5		
Arthropoda															
Crustacea															
Malacostraca															
Amphipoda															
Corophium spinicorne					96							3	18	4.5	295.5
Insecta															
Plecoptera															
Nemouridae															
Nemoura columbiana															
Perlodidae															
Isogenus frontalis															
Odonata															
Agrionidae															
Argia sedula															
Argia sp.															
Gomphidae															
Hagenius sp.															
Ephemeroptera															
Baetidae															
Baetis sp.															
Pseudocloeon sp.															
Trichoptera															
Rhyacophilidae															
Agapetus sp.															
Psychomyiidae															
Polycentropus sp.															
Psychomyia sp.															
Hydropsychidae															
Hydropsyche sp.	.8														
Hydropilidae															
Ochrotrichia sp.															
Lepidostomatidae															
Lepidostoma sp.															
Brachycentridae															
Coleoptera															
Dytiscidae															
Oreodytes sp.															
Dryopidae															
Helichus sp.															
Elmidae															
Dubiraphia sp.															
Diptera															
Tanyderidae															
Tipulidae															
Antocha sp.															
Blephariceridae															
Simuliidae															
Simulium arcticum															
Simulium sp.															
Tendipedidae										6					
Diamesa spp.															
Pelopiinae															
Pentaneura spp.									1.5	1.5					
Procladius sp.															
Tendipedinae															
Tendipes plumosus															
Tendipes spp.	.8						4.5	.8	3	4.5			3		
Calopsectera															
Polypedilum sp.	16.5	7.5					6	2.3	7.5						
Pentapedilum spp.						7.5						3			
Cryptochironomus spp.							15		10.5		1.5	3	1.5	1.5	

TABLE 7 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per squore foot

SEPTEMBER 1960

CLASSIFICATION	RIVER MILES																												
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	2 7 6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/O1	88.2	81.5	80.8 L.O1	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Hydrobaeninae																														
Corynoneura sp.								.7										13.5												
Cricotopus sp.		.7																												
Spaniotoma sp.		1																												
Heleidae																														
Empididae																														
Hemerodromia sp.		.3			.7																									
Acari																														
Hydracarina		1.7			.7		1.3	.3	5.3																					
Mollusca																														
Physidae																														
Physa sp.				.3																										
Sphaeriidae																														
Pisidium sp.	114																													
Corbiculidae																														
Corbicula fluminea																			1.5	1.5	7.5	1.5	22.5	3					4.5	1.5	3
Vertebrata																														
Petromyzontidae																														
Lampetra sp.													1.5										1.5							
Cottidae																														
Cottus gulosus									.3																					

TABLE 8

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

OCTOBER 1960

CLASSIFICATION	RIVER MILES																														
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	276	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/O	88.2	81.5	80.8 L/O	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Platyhelminthes																															
Planariidae				.7																											
Dugesia sp.					3		1		1																						
Nemathelminthes																															
Nematoda		2			4		6	2																							
Bryozoa																															
Lophopodidae																															
Pectinatella magnifica																														1.5	
Annelida																															
Oligochaeta	157.5	2	91.5	1	28		30		2	42	2		117	73.5	31.5			30		10.5			1.5	43.5	18	144	12	90	19	141	12
Naididae																															
Chaetogaster sp.		1			3		10	1			.3																				
Stylaria sp.	18																														
Nereidae																															
Neanthes limnicola																										1.5	1.5				
Glossiphoniidae																															
Placobdella monilifera			1.5																												
Arthropoda																															
Crustacea																															
Clodocera																															
Chydoridae																															
Eurycercus sp.		.3																													
Daphnidae																															
Daphnia sp.					1																										
Copepoda																															
Cyclopida																1.5															3
Canthocamptidae								1																							
Harpacticoida sp.					1		4		1																						
Malacostraca																															
Amphipoda																															
Corophium spinicorne																					31.5					6			36	7.5	363
Insecta																															
Plecoptera																															
Pteronarcidae																															
Pteronarcys sp.											.7																				
Perlodidae																															
Isogenus frontalis																															
Isogenus sp.								4	1		2																				
Odonata																															
Agrionidae																															
Enallagma sp.			3																												
Ephemeroptera																															
Baetidae																															
Baetis sp.				4.3	51		86	12	39		15																				
Pseudocloeon sp.		.7		1.3	17				4		5					3															
Trichoptera																															
Rhyacophilidae																															
Agapetus sp.		.7		3.7	25		26	50	2																						
Psychomyiidae																															
Polycentropus sp.								3																							
Hydropsychidae																															
Hydropsyche sp.		.3			49		767	146	407	1.5	114																				
Hydroptilidae																															
Ochrotrichia sp.		61.7		4	54			2				.8		3																	
Leptoceridae												.8																			
Lepidostomatidae																															
Lepidostoma sp.		99.3			4				2																						
Brachycentridae							1																								
Brachycentrus sp.																															
Coleoptera									1																						
Dytiscidae																															
Oreodytes sp.		1.3																													
Dryopidae																															
Helichus sp.											1.7																				
Elmidae																															
Narpus sp.								1																							
Neoelmis sp.							1																								
Diptera																															
Tanyderidae																	9														
Protanyderus sp.											.7																				
Tipulidae																															
Antocha sp.				.3	110		7	2	5																						
Culicidae																															
Chaoborus punctipennis			1.5																												
Simulidae																															
Simulium arcticum								4			35.7																				
Simulium canadense					3																										
Simulium sp.				.3			2		1	3					4.5																
Tendipedidae		51.7		7.3	333		184	206	7											1.5											
Diamesinae				1																											

TABLE 8 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

OCTOBER 1960

CLASSIFICATION	RIVER MILES																														
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	2 7 6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/O	88.2	81.5	80.8 L/O	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Diamesa spp.											.7																				
Pelopiinae	1.5																														
Pelopia punctipennis			4.5																												
Tendipedinae																															
Tendipes plumosus										9																					
Tendipes spp.			13.5										30	1.5	3			1.5						4.5		3			1.5		
Calopsectra spp.								21	18		10																				
Tanytarsus sp.										55.5	1.3															1.5					
Polypedilum sp.													39					4.5					6	1.5	6	1.5			6		
Cryptochironomus stylifera											.3																	3			
Cryptochironomus spp.				.3						4.5		18	6	12	7.5	52.5		15					13.5						4.5	1.5	
Hydrobaeninae																															
Corynoneura sp.								1			.3																				
Hydrobaenus sp.			1.5						3																						
Metriocnemus sp.												.8																			
Cardiocladius sp.											3.3																				
Cricotopus sp.									3																						
Empididae																															
Hemerodromia sp.		4.3													1.5																
Ephydridae																															
Hydrellia sp.			3																												
Sciomyzidae																															
Sepedon sp.					1																										
Acari																															
Hydracarina		27.7			2			1		1.5																					
Mollusca																															
Planorbidae																															
Gyraulus sp.	1.5																														
Sphaeriidae																															
Pisidium sp.	19.5																														
Corbiculidae																															
Corbicula fluminea																				3	1.5		55.5				13.5			1.5	1.5
Vertebrata																															
Cottidae																															
Cottus asper				.3																											

TABLE 9

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

NOVEMBER 1960

CLASSIFICATION	RIVER MILES 305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2	144.1
Porifera																
Spongillidae																
Spongilla fragilis																
Platyhelminthes																
Planariidae																
Dugesia sp.				.3	4.3		5		.7							
Nemathelminthes																
Nematoda		.3		1.7	6.3	15		5			1.7					
Annelida																
Oligochaeta	6174	1.3	42		63	3	13		5.7	2.3	.7	5.3		39		
Naididae																
Chaetogaster sp.		.7			3.3		6	1			.3					
Nais sp.						1	2	3.3								
Tubificidae																
Branchiura sowerbyi																
Nereidae																
Neanthes limnicola																
Glossiphoniidae	3								.3	.7						
Arthropoda																
Crustacea																
Clodocera																
Copepoda																
Cyclopida																
Cyclops sp.				1.3					.3							
Eucyclops sp.					2.3											
Canthocamptidae																
Harpacticoida sp.						1		1.3								
Canthocamptus sp.							128									
Malacostraca																
Amphipoda																
Corophium spinicorne																
Insecta																
Plecoptera																
Nemouridae																
Nemoura sp.									.3							
Brachyptera sp.																
Perlodidae																
Isogenus frontalis																
Isogenus sp.					.3			2.7	.3		1.7					
Ephemeroptera																
Baetidae																
Baetis sp.				.7	23.3	22	120	4	20	2.7	39.7					
Pseudocloeon sp.				5.7	9	18	85	1	5	1	18.7					
Tricorythidae																
Tricorythodes fallax										.3						
Trichoptera																
Rhyacophilidae																
Agapetus sp.		1.3		40.3	25	54	68	67	2.7	7.7	9.3					
Psychomyiidae																
Polycentropus sp.								3.3								
Psychomyia sp.									.3							
Hydropsychidae																
Hydropsyche sp.		.3			25.7	163	564	78.3	47	95	84.7					
Hydroptilidae																
Ochrotrichia sp.		94		28.7	219.7		10			4			3			
Leptoceridae																
Leptocella sp.									.3							
Leptocerus sp.									3.3							
Lepidostomatidae																
Lepidostoma sp.		45		.3	19.3											
Lepidoptera																
Pyralidae																
Parargyractis truckeealis						1										
Coleoptera																
Dytiscidae																
Oreodytes sp.		1														
Hymenoptera																
Mymaridae											.3					
Diptera																4.5
Tipulidae																
Antocha sp.				.7	75.3	29	26	.7	4	3	1.3					
Psychodidae																
Psychoda sp.					.3											
Simuliidae													1.5			
Simulium sp.		.3		.7	4.7	2	7	2.3								
Tendipedidae				37.3	225.3	125	820	18.7	4	78.7	3					
Diamesa spp.		12.3							4							
Pelopiinae																
Pentaneura spp.									3							
Procladius sp.			1.5													

CLASSIFICATION	RIVER MILES 118.1	90.5	90.2 R/O	88.2	81.5	80.8 L/O	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Porifera															
Spongillidae															
Spongilla fragilis									X	X					
Platyhelminthes															
Planariidae															
Dugesia sp.															
Nemathelminthes															
Nematoda															
Annelida															
Oligochaeta						12		25.5	51	52.5	16.5	186	9	150	19.5
Naididae															
Chaetogaster sp.															
Nais sp.															
Tubificidae															
Branchiura sowerbyi			4.5												
Nereidae															
Neanthes limnicola											1.5				
Glossiphoniidae															
Arthropoda															
Crustacea															
Clodocera									1.5						
Copepoda															
Cyclopida															
Cyclops sp.	.8														
Eucyclops sp.															
Canthocamptidae															
Harpacticoida sp.															
Canthocamptus sp.															
Malacostraca															
Amphipoda															
Corophium spinicorne					9							1.5	126	36	147.5
Insecta															
Plecoptera															
Nemouridae															
Nemoura sp.															
Brachyptera sp.															
Perlodidae															
Isogenus frontalis															
Isogenus sp.															
Ephemeroptera															
Baetidae															
Baetis sp.															
Pseudocloeon sp.															
Tricorythidae															
Tricorythodes fallax															
Trichoptera															
Rhyacophilidae															
Agapetus sp.															
Psychomyiidae															
Polycentropus sp.															
Psychomyia sp.															
Hydropsychidae															
Hydropsyche sp.															
Hydroptilidae															
Ochrotrichia sp.															
Leptoceridae															
Leptocella sp.															
Leptocerus sp.															
Lepidostomatidae															
Lepidostoma sp.															
Lepidoptera															
Pyralidae															
Parargyractis truckeealis															
Coleoptera															
Dytiscidae															
Oreodytes sp.															
Hymenoptera															
Mymaridae															
Diptera	9			1.5			3								
Tipulidae															
Antocha sp.															
Psychodidae															
Psychoda sp.															
Simuliidae															
Simulium sp.															
Tendipedidae															
Diamesa spp.															
Pelopiinae															
Pentaneura spp.															
Procladius sp.															

TABLE 9 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per squore foot

NOVEMBER 1960

CLASSIFICATION	RIVER MILES 305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2
Tendipedinae															
Tendipes plumosus			9											1.5	
Tendipes spp.													3		
Calopsectra flavellus								.3	.7						
Calopsectra spp.							2				23.7				
Tanytarus (endochironomus) sp.													3		
Tanytarsus (stichtochironomus) sp.															
Polypedilum flavus													24	12	
Pentapedilum spp.												6.8			
Cryptochironomus sp.			3									9.8		3	15
Limnochironomus sp.						1									
Hydrobaeninae		.7													
Corynoneura sp.								.7							
Cricotopus sp.								3.3							
Orthocladius sp.						1									
Spaniotoma (eukiefferiella) sp.						1	3								
Empididae															
Hemerodromia sp.		1		.7	1	1	2	.3							
Anthomyiidae															
Limnophora aquifrons				.7	1										
Acari															
Hydracarina		5		.3	22.7	2	23				.7				
Halacaridae		1													
<u>Mollusca</u>															
Physidae															
Physa sp.	7.5														
Planorbidae															
Gyraulus sp.	54														
Helisoma sp.		.3													
Sphaeriidae	78														
Corbiculidae															
Corbicula fluminea															
<u>Vertebrata</u>															
Petromyzontidae															
Lampetra sp.	3														

CLASSIFICATION	RIVER MILES 144.1	118.1	90.5	90.2 R/0.1	88.2	81.5	80.8 L/0.1	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Tendipedinae																
Tendipes plumosus																
Tendipes spp.							13.5		1.5	3	6					
Calopsectra flavellus																
Calopsectra spp.																
Tanytarus (endochironomus) sp.																
Tanytarsus (stichtochironomus) sp.								7.5								
Polypedilum flavus																
Pentapedilum spp.													3			
Cryptochironomus sp.			4.5						6	3		3				
Limnochironomus sp.																
Hydrobaeninae																
Corynoneura sp.																
Cricotopus sp.																
Orthocladius sp.																
Spaniotoma (eukiefferiella) sp.																
Empididae																
Hemerodromia sp.																
Anthomyiidae																
Limnophora aquifrons																
Acari																
Hydracarina																
Halacaridae																
<u>Mollusca</u>																
Physidae																
Physa sp.																
Planorbidae																
Gyraulus sp.																
Helisoma sp.																
Sphaeriidae																
Corbiculidae																
Corbicula fluminea				7.5	7.5	3	1.5	48	19.5			9		24		3
<u>Vertebrata</u>																
Petromyzontidae																
Lampetra sp.																

TABLE 10

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

DECEMBER 1960

CLASSIFICATION	RIVER MILES																														
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/01	88.2	81.5	80.8 L/01	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
<u>Platyhelminthes</u>																															
Planariidae																															
Dugesia sp.					1	5																									
<u>Nemathelminthes</u>																															
Nematoda					3.3	95															1.5										
Annelida																															
Oligochaeta		81.7			6.7	5	4.3			.3		1.5						24							67.5		9		43.5	175.5	16.5
Naididae																															
Chaetogaster sp.					1.3	3	.3																								
Nais sp.						13	.7																								
<u>Arthropoda</u>																															
Crustacea																															
Clodocera																															
Copepoda																															
Cyclopida																															1.5
Canthocamptidae																															
Harpacticoida sp.		.7				120																									
Malacostraca																															
Amphipoda																															
Corophium spinicorne																		1.5			711								94.5	42	222
Insecta																															
Plecoptera																															
Nemouridae																															
Paracapnia sp.							.3																								
Perlodidae																															
Isogenus sp.					.3					1.7	.7																				
Odonata																															
Ephemeroptera																															
Baetidae																															
Baetis sp.					21.3	5	1			27.7																					
Pseudocloeon sp.				.3						1.7																					
Neuroptera																															
Sialidae																															
Sialis sp.		1																													
Trichoptera																															
Rhyacophilidae																															
Agapetus sp.				25.7	5	89	59.7			19	.7																				
Psychomyiidae																															
Polycentropus sp.						11																									
Hydropsychidae																															
Hydropsyche sp.				.7	9.7	209	43			15.3	.7	.8																			
Hydroptilidae																															
Ochrotrichia sp.		1761.7		9	12.7	21	3			1		.8																			
Lepidostomatidae																															
Lepidostoma sp.		46.7		1	2.7																										
Coleoptera																															
Dytiscidae																															
Oreodytes sp.		1																													
Dryopidae																															
Helichus sp.					.3																										
Elmidae																															
Limnius sp.							.7																								
Hymenoptera																															
Hymaridae																															
Pataeson sp.										.3																					
Figitidae																															
Diptera																															
Tanyderidae																2.3							9								
Protanyderus sp.							.3				.3																				
Tipulidae																															
Antocha sp.					2.7	25	5.7			4																					
Simulidae																															
Simulium arcticum										.7																					
Simulium sp.					1.3		2.3																								
Tendipedidae		5.3				292	25.3			9.3	.3																				
Palopiinae																															
Pentaneura spp.		.3																													
Tandipedinae																															
Tendipes spp.																															
Calopsectra exiguus							4																							1.5	
Stenochironomus sp.																.8							9								
Polypedilum sp.												.8																			
Pantapedilum spp.				.3																											
Cryptochironomus spp.												.8															3		1.5		
Limnochironomus sp.		.3		.3																											
Hydrobaeninae																															
Hydrobaenus sp.					32					1.7																					
Cricotopus sp.				.3																											
Spaniotoma (eukiefferiella) sp.				.3																											
Empididae																															
Hemerodromia sp.		3			.3	1	.3																								

TABLE 10 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

DECEMBER 1960

CLASSIFICATION	RIVER MILES																													
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	27.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/O1	88.2	81.5	80.8 L O1	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Acari																															
Hydracarina		69.3		.3	1.3	6	3			1.7																					
<u>Mollusca</u>																															
Planorbidae																															
Gyraulus sp.												.8																			
Corbiculidae																															
Corbicula fluminea																							4.5				3		1.5	3	6

TABLE II

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

JANUARY 1961

CLASSIFICATION	RIVER MILES																														
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/O	88.2	81.5	80.8 L/O	62.6	53.2	46.4	43.4	37.2	27.4	18.8	2.8	4.0
Platyhelminthes																															
Planariidae																															
Dugesia sp.		.7			.7	2.3																									
Nemathelminthes																															
Nematoda				.7			1			.7	1.7										16.5										
Annelida																															
Oligochaeta		8.3			7.7	1.7				1	.3						1.5						3.8	45	12		1.5	324	84		6
Naididae																															
Chaetogaster sp.				.3	.3	.3	.3																								
Nais sp.				.3		5																									
Tubificidae																															
Branchiura sowerbyi																								3							
Nereidae																															
Neanthes limnicola																											1.5		4.5		
Arthropoda																															
Crustacea																															
Copepoda																															
Canthocamptidae																															
Harpacticoida sp.					.3	1																									
Malacostraca																															
Amphipoda																															
Corophium spinicorne																	52.5				1,245		1.5						33		331.5
Insecta																															
Plecoptera																															
Nemouridae										.7																					
Nemoura columbiana																															
Perlodidae																															
Isogenus frontalis										.7	1.3																				
Isogenus sp.										.7																					
Isoperla sp.								.3		3.7																					
Ephemeroptera																															
Baetidae																															
Baetis sp.					35.3	9.3	4	5		20	4.7																				
Neuroptera																															
Sialidae																															
Sialis sp.		.3																													
Trichoptera																															
Rhyacophilidae																															
Agapetus sp.		1		3.7	7.3	221.7	40.7	8		27	1.3																				
Hydropsychidae																															
Hydropsyche sp.					5.7	77.3	6.3	2.3		24.3	1																				
Hydroptilidae																															
Ochrotrichia sp.		984.7		17.3	9.7	7	.7			.3																					
Lepidostomatidae																															
Lepidostoma sp.		27.7		.7	3.3	4																									
Coleoptera																															
Dytiscidae																															
Oreodytes		.7		.3																											
Diptera																															
Tanyderidae																															
Protanyderus sp.											.7																				
Tipulidae																															
Antocha sp.				.3		6	2			5																					
Tendipedidae		55				19	17.3	2.3		27.3																					
Prodiamesa sp.																							.8								
Pelopiinae																															
Pentaneura spp.		.3																													
Tendipedinae																															
Tendipes spp.																							.8								
Calopsectra spp.						.3					.3																		4.5		
Tanytarsus (endochironomus) sp.															7.5																
Tanytarsus sp.											.3																				
Polypedilum sp.																													1.5		
Pentapedilum spp.							.3																								
Cryptochironomus sp.															.8								2.3	13.5	1.5				1.5		
Hydrobaeninae																															
Hydrobaenus sp.				14.7																											
Cardiocladius sp.							.3																								
Spaniotoma (eukiefferiella) sp.							.7																								
Heleidae																							.8								
Dasyhelea sp.						.3																									
Empididae																															
Hemerodromia sp.		.3		.3			.3				.3																				
Acari																															
Hydracarina		6.7			.7	1.3	1																								
Mollusca																															
Corbiculidae																															
Corbicula fluminea																							9		12		36		6		13.5

TABLE 12

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

FEBRUARY 1961

CLASSIFICATION	RIVER MILES																														
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/O	88.2	81.5	80.8 L/O	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Porifera																															
Spongillidae																															
Spongilla fragilis																									X						
Platyhelminthes																															
Planariidae																															
Dugesia sp.											.3																				
Nemathelminthes																															
Nematoda					3.7	2.5																									
Bryozoa																															
Lophopodidae																															
Pectinatella magnifica																															
Annelida																															
Oligochaete	15			.3	10.3	3				1.7	.3							19.5							252		31.5		79.5	102	30
Naididae																															
Chaetogaster sp.				.3																											
Stylaria sp.	4.5																														
Arthropoda																															
Crustacea																															
Copepoda																															
Canthocamptidae																															
Harpacticoida sp.					.3	.5																									
Malacostraca																															
Amphipoda																															
Corophium spinicorne																											1.5		6	45	546
Insecta																															
Plecoptera																															
Nemouridae																															
Eucapnopsis sp.										.7																					
Odonata																															
Agrionidae																															
Argia emma					.3																										
Ephemeroptera																															
Baetidae																															
Baetis sp.					42	2	21			5.3	1.3																				
Trichoptera																															
Rhyacophilidae																															
Agapetus sp.				21	12.3	87.5	156			21.3	.3																				
Hydropsychidae																															
Hydropsyche sp.				.3	1.3	27	10.3			34.7																					
Hydroptilidae																															
Ochrotrichia sp.				13.3	12.7	1.5	4			1.3																					
Lepidostomatidae																															
Lepidostoma sp.				.3	4.3																										
Coleoptera																															
Dytiscidae				.3																											
Psephenidae																															
Psephenus sp.							1																								
Hydrophilidae										.3																					
Diptera																															
Tanyderidae																															
Protanyderus sp.											.3																				
Tipulidae																															
Antocha sp.				58.3	15.3	9	39			16.7																					
Psychodidae																															
Psychoda alternata					.3																										
Simulidae																															
Simulium sp.										.3																					
Tendipedidae					70.3	49.5	19			10.7																			1.5		
Tendipedinae																															
Tendipes parilus												37.5																			
Calopsectra spp.												.8																			
Tanytarsus (endochironomus) sp.												.8																			
Polypedilum flavus																													1.5		
Polypedilum sp.											.7																				
Cryptochironomus spp.																		7.5											7.5		
Empididae																															
Hamerodromia sp.					1		1			.7																					
Acari																															
Hydracarina				.7	.7	1	3			.7																					
Mollusca																															
Planorbidae																															
Gyraulus sp.	9																														
Corbiculidae																															
Corbicula fluminea																						10.5		13.5				10.5		16.5

TABLE 13

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

MARCH 1961

CLASSIFICATION	RIVER MILES																														
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/O1	88.2	81.5	80.8 L/O1	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Annelida																															
Oligochaeta													3.8		8.3									73.5	7.5		37.5	333	1.5		3
Tubificidae																															
Branchiura sowerbyi																												3			
Nereidae																															
Neanthes limnicola																											1.5				
Arthropoda																															
Crustacea																															
Malacostraca																															
Amphipoda																															
Corophium spinicorne																								10.5							339
Diptera																															
Psychodidae																															
Psychoda alternata																												1.5			
Tendipedidae													1.5																		
Tendipedinae																															
Tanytarsus (stichtochironomus) sp.															.8																
Lauterborniella sp.																							4.5								
Cryptochironomus fulvus															.8		1.5				3		1.5								
Cryptochironomus spp.													3.8		.8									7.5	3		1.5	1.5			
Heleidae																								1.5							
Probezzia sp.																												1.5			
Ephydridae																															
Acari																															
Hydracarina																								1.5							
Mollusca																															
Corbiculidae																															
Corbicula fluminea																							1.5	103.5	1.5		1.5	1.5	.8		10.5

TABLE 14

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

APRIL 1961

CLASSIFICATION	RIVER MILES																														
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/O1	88.2	81.5	80.8 L/O1	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Platyhelminthes																															
Planariidae																															
Dugesia sp.				1		3																									
Nemathelminthes																															
Nematoda	3			.7		3																									
Annelida																															
Oligochaeta	57			1.7		1	4				.3			22.5				58.5							7.5		31.5				
Naididae																															
Stylaria sp.	33																														
Tubificidae																															
Branchiura sowerbyi																													4.5		
Nereidae																															
Neanthes limnicola																											1.5		3		
Glossiphoniidae	1.5																														
Arthropoda																															
Crustacea																															
Malacostraca																															
Amphipoda																															
Corophium spinicorne																													1.5	102	136.5
Insecta																															
Plecoptera																															
Perlodidae																															
Isogenus sp.										.7																					
Isoperla sp.											.3																				
Odonata																															
Ephemeroptera																															
Baetidae																															
Baetis sp.				.7			2.5			3.7	1																				
Pseudocloeon sp.						4	5			9.7	10.7																				
Ephemerellidae																															
Ephemerella euterpe										1																					
Ephemerella sp.							.5																								
Heptageniidae																															
Pseudiron sp.																							1.5								
Trichoptera																															
Rhyacophilidae																															
Agapetus sp.				6.3		128	37.5			5.7																					
Hydropsychidae																															
Hydropsyche sp.						52	48.5			9	1.7																				
Hydroptilidae																															
Ochrotrichia sp.				4.3			1.5			.3																					
Coleoptera																															
Dytiscidae																.8															
Psephenidae																															
Psephenus sp.							.5				.3																				
Elmidae											.3																				
Narpus sp.							.5				.3																				
Diptera																															
Tipulidae																															
Antocha sp.				.7		9	16.5			7.3																					
Simuliidae							.5																								
Tendipedidae				58		32	46.5																								
Pelopiinae																															
Pentaneura spp.						1																									
Tendipedinae																															
Tendipes decorus										.3																					
Tendipes spp.																													1.5		
Tanytarsus (stichtochironomus) sp.												1.5																			
Polypedilum flavus														3																	
Polypedilum sp.														1.5		9.8		1.5													
Pentapedilum spp.										1																					
Cryptochironomus fulvus																											1.5				
Cryptochironomus spp.	3											19.5				18		7.5							3				3		
Hydrobaeninae																															
Hydrobaenus sp.										1	2.3																				
Spaniotoma (eukiefferiella) sp.						5				1.7																					
Brillia sp.	1.5																														
Empididae																															
Hemerodromia sp.						1	1.5																								
Acari																															
Hydracarina				.7		1	3				1																				
Mollusca																															
Planorbidae																															
Gyraulus sp.	1.5																														
Sphaeriidae																															
Pisidium sp.	51																														
Corbiculidae																															
Corbicula fluminea																							93		9		3		4.5	19.5	

TABLE 14 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

APRIL 1961

CLASSIFICATION	RIVER MILES																														
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/O.I	88.2	81.5	8.8 [illegible]	62.6	53.2	46.4	43.4	37.2	27.4	18.8	2.8	4.0
Vertebrata																															
Petromyzontidae																															
Lampetra sp.																.8															

TABLE 15

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

MAY 1961

CLASSIFICATION	RIVER MILES																									
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	207.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/01	88.2	81.5	80.8 L/01	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Platyhelminthes																															
Planariidae																															
Dugesia sp.					.3	2																									
Nemathelminthes																															
Nematoda						5					2																				
Annelida																															
Oligochaeta		.7			1.7	5.7							16.5		10.5						1.5			168	82.5		238.5	163.5	25.5		1.5
Naididae																															
Chaetogaster sp.		.3				1																									
Nais sp.		.7																													
Nereidae																															
Neanthes limnicola																								1.5	6			3	9		
Arthropoda																															
Crustacea																															
Copepoda																															
Canthocamptidae																															
Harpacticoida sp.						.7					.3																				
Malacostraca																															
Amphipoda																															
Corophium spinicorne																							10.5								150
Mysidacea																															
Peracarida																															
Neomysis mercedis																															1.5
Insecta																															
Plecoptera																															
Perlodidae																															
Isogenus sp.											1.3																				
Isoperla sp.								.3																							
Odonata																															
Ephemeroptera																															
Baetidae																															
Baetis sp.					16.7			3.7																							
Pseudocloeon sp.		.7			7.7	14.3		8			77																				
Ephemerellidae																															
Ephemerella sp.											.3																				
Trichoptera																															
Rhyacophilidae																															
Agapetus sp.					28.3	71.7		6			2.3																				
Psychomyiidae																															
Polycentropus sp.								.3			.3																				
Hydropsychidae																															
Hydropsyche sp.					4.3	35.3		25.7			7.7																				
Hydroptilidae																															
Ochrotrichia sp.		2			2	.8																									
Lepidostomatidae																															
Lepidostoma sp.					2	.3																									
Lepidoptera																															
Pyralidae																															
Parargyractis truckeealis					.3																										
Coleoptera																															
Dytiscidae											.3																				
Agabinus sp.		.7																													
Oreodytes sp.		1.3																													
Psephenidae																															
Psephenus sp.								.3																							
Elmidae																															
Narpus sp.								.3																							
Hydrophilidae																															
Diptera																															
Tanyderidae																															
Protanyderus sp.																															
Tipulidae											.3																				
Antocha sp.					6.3	5		109.3																							
Psychodidae																															
Telmatoscopus sp.						.3																									
Simuliidae																															
Simulium sp.											5																				
Tendipedidae		48.7			216.7	394					20.3						25.5														
Pelopiinae																															
Pentaneura spp.											.3																				
Tendipedinae																															
Tendipes militaris													31.5																		
Tanytarsus (endochironomus) sp.															6												1.5				
Polypedilum sp.													84		1.5																
Cryptochironomus spp.															1.5						25.5		4.5		3		1.5		3		
Heleidae																															
Palpomyia sp.															1.5																
Dasyhelea longipalpus											.3																				
Empididae																															
Hemerodromia sp.											1.3																				
Anthomyiidae																															

TABLE 15 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

MAY 1961

CLASSIFICATION	RIVER MILES 305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5
Limnophora aquifrons														
Ephydridae														
Acari					.3									
Hydracarina					2.3	4		1						
Mollusca														
Corbiculidae														
Corbicula fluminea														
Vertebrata														
Petromyzontidae														
Lampetra sp.													–	

CLASSIFICATION	168.2	144.1	118.1	90.5	90.2 R/O1	88.2	81.5	80.8 L/O1	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Limnophora aquifrons																	
Ephydridae																	
Acari																	
Hydracarina																	
Mollusca																	
Corbiculidae																	
Corbicula fluminea							1.5		30	9	3		6		6		
Vertebrata																	
Petromyzontidae																	
Lampetra sp.	3		4.5														

TABLE 16

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

JUNE 1961

CLASSIFICATION	RIVER MILES																													
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	217.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/01	88.2	81.5	80.8 L/01	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Porifera																															
Spongillidae																															
Spongilla fragilis																											X				
Platyhelminthes																															
Planariidae																															
Dugesia sp.				.3																											
Nemathelminthes																															
Nematoda				2		5				1.7	.7																				
Annelida																															
Oligochaeta				5.7		41.3	6			.7	.3	6.8		37.5		12.8		3					14.3		36		34.5		7.5	105	3
Naididae																															
Chaetogaster sp.				8.7		1	1																								
Nais sp.							.3				.7																				
Tubificidae																															
Branchiura sowerbyi																		1.5													
Nereidae																															
Neanthes limnicola																									6				9		
Arthropoda																															
Crustacea																															
Copepoda																															
Canthocamptidae																															
Harpacticoida sp.						.3																									
Malacostraca																															
Amphipoda																															
Corophium spinicorne																									4.5				1.5	16.5	316.5
Insecta																															
Plecoptera																															
Perlodidae																															
Isogenus sp.							.7																								
Odonata																															
Gomphidae																															
Erpetogomphus sp.														1.5																	
Ephemeroptera																															
Baetidae																															
Baetis leechi												1.5																			
Baetis bicaudatus				.3																											
Baetis sp.				16.7		17.3	17.3			27.7	36.7																				
Pseudocloeon sp.				3.7		4.3	2.7			2																					
Hemiptera																															
Corixidae											.3																				
Trichoptera																															
Rhyacophilidae																															
Agapetus sp.				5.7		33.3	4.3			2																					
Psychomyiidae																															
Polycentropus sp.							3			1	.3																				
Hydropsychidae																															
Hydropsyche sp.						28.7	9.7			9.3	1																				
Hydroptilidae																															
Ochrotrichia sp.				14		2	3.3																								
Lepidostomatidae																															
Lepidostoma sp.						.7					.3																				
Brachycentridae																															
Brachycentrus sp.							1																								
Coleoptera																															
Dytiscidae																															
Oreodytes bisulcatus				.3																											
Oreodytes sp.						.3					.3																				
Psephenidae																															
Psephenus sp.											.3																				
Diptera																															
Tanyderidae																															
Protanyderus sp.											.3																				
Tipulidae																															
Antocha sp.						4.7	3.3				.3																				
Blephariceridae																															
Blepharicera sp.											.3																				
Simuliidae																															
Simulium argus										2.7	12																				
Simulium sp.							2																								
Tendipedidae	21			124.7		224	259.3			25.7	13.3																				
Diamesa spp.	1.5																														
Prodiamesa sp.																.8															
Tendipedinae																															
Tendipes militaris														12																	
Tendipes dispar	3																														
Tendipes spp.												17.3				.8							6				7.5				
Calopsectra spp.	1.5																														
Polypedilum sp.	4.5																										1.5				
Pentapedilum spp.												7.5		3																	

TABLE 16 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

BOTTOM ORGANISMS

Adjusted number per square foot

JUNE 1961

CLASSIFICATION	RIVER MILES																														
	305.7	297.7	295.5	294.0	285.9	279.2	275.0	256.3	253.4	241.0	229.8	227.6	199.6	184.5	168.2	144.1	118.1	90.5	90.2 R/O1	88.2	81.5	80.8 L/O1	62.6	53.2	46.4	43.4	37.2	27.4	18.8	12.8	4.0
Cryptochironomus spp.												1.5		4.5		.8		6					2.3				6			4.5	
Hydrobaeninae																															
Hydrobaenus sp.	4.5																														
Heleidae						.3	.3																								
Empididae																															
Hemerodromia sp.						.3	2.3																.8								
Anthomyiidae																															
Limnophora aquifrons						.3																									
Ephydridae				.3																											
Hydrellia sp.																															
Acari																															
Hydracarina						2.7	1.3			.7																					
Mollusca																															
Planorbidae																															
Gyraulus sp.	13.5																														
Sphaeriidae																															
Pisidium sp.	10.5																														
Corbiculidae																															
Corbicula fluminea																							2.3		1.5				4.5		
Vertebrata																															
Petromyzontidae																															
Lampetra sp.												.8		10.5		.8		7.5													

long runs and pools (approximately mile 229 to mile 145); (3) the lower-middle river, which consists of a dredged channel with levees (approximately mile 145 to mile 19); and (4) the lower river, which consists of a broad tidal channel, also dredged and with levees.

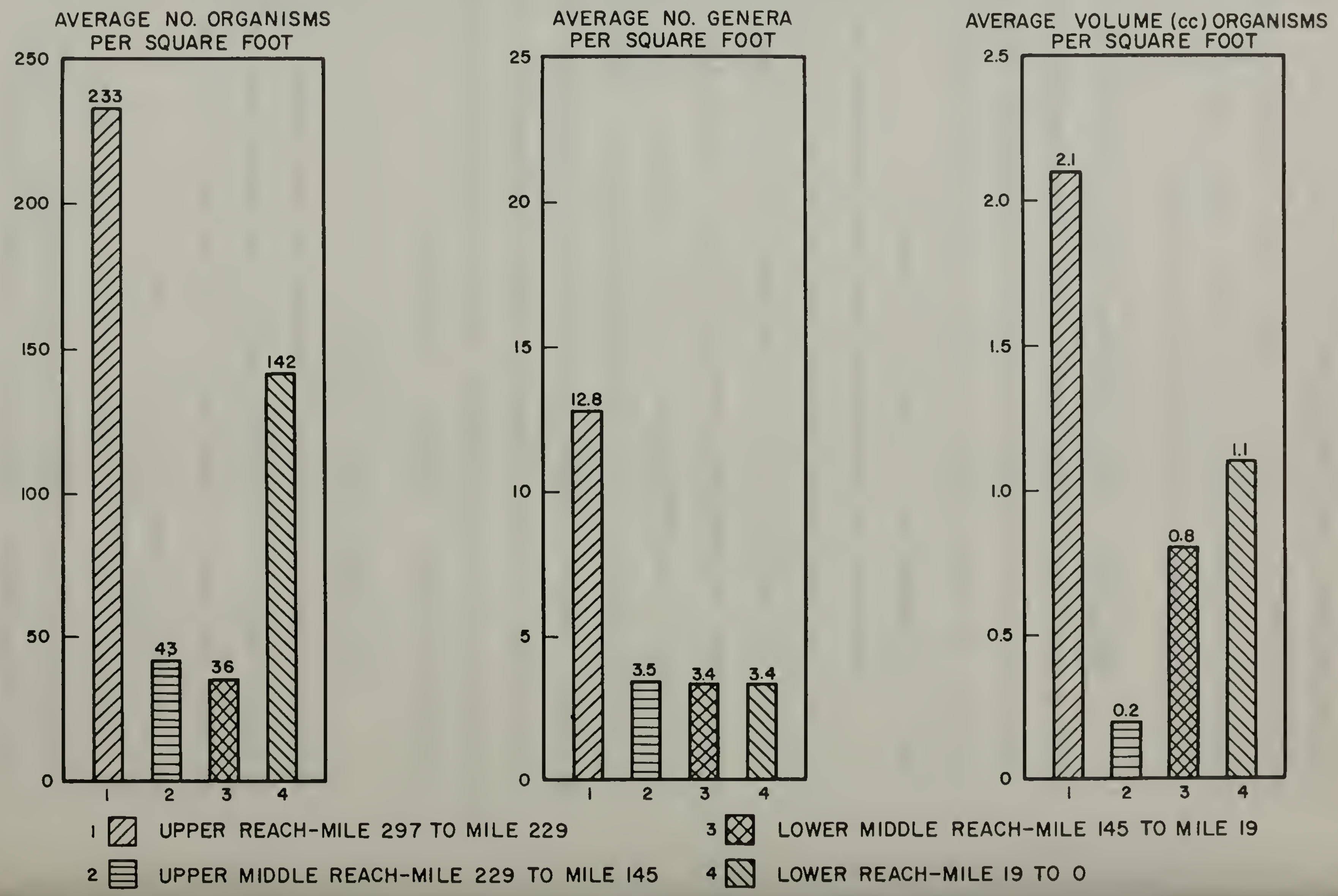
Upper Reach. Aquatic organisms collected from the river bottom exhibited wide variations from reach to reach. Three representative stations were selected from each reach and the average numbers of organisms, and genera, and average volumes per square foot for each reach were determined. This information is presented in Figure 15.

Thirty-nine collections were made during the survey at the three stations in the upper reach. Station locations were at mile 285.9, mile 275.0, and mile 229.8, all of which were located on riffle areas. The average numbers of organisms, genera, and average volume of these samples was much greater than that for any of the other reaches. Riffle areas are generally considered to be more productive of aquatic organisms than pool areas. Dominant organisms in this reach were oligochaetes and insects. Of the insects, the orders Plecoptera, Odonata, Ephemeroptera, Tricoptera, and Diptera were the most important. Families of Diptera collected most often were Tendipedidae, Tipulidae, and Simulidae.

Upper-Middle Reach. Thirty-three samples were taken from stations in the upper-middle reach. These stations were located at mile 217.6, mile 199.6, and mile 168.2. All of these samples were taken from pool areas near shore in water from 7 to 25 feet deep. No attempt was made to sample organisms in the riffle areas of this reach. The numbers of organisms collected were rather low, with few kinds present. The volume of these organisms was extremely low, averaging only 0.2 cc. per square foot of bottom sampled. This was only one-fourth to one-tenth the volume

FIGURE 15

NUMBERS, DIVERSITY AND VOLUMES OF AQUATIC ORGANISMS
APRIL, 1960 THROUGH JUNE, 1961



found in the other reaches. All of the organisms collected in this reach were quite small. Most of those collected were oligochaetes and midge larvae (Tendipedidae).

Lower-Middle Reach. The lower-middle reach was represented by 42 samples taken at mile 90.5, mile 62.6, and mile 37.2. This stretch of river is characterized by a rather uniform sandy bottom this quite unproductive of bottom organisms. The numbers of organisms per unit of area were lower in this reach of the river than in any of the others, but the volume was higher than in the upper-middle reach. The collection of a few large clams, Corbicula, was primarily responsible for the increased volume over the reach immediately upstream. There was little variety in types of organisms present. Most of those collected were clams, oligochaetes, and midge larvae.

Lower Reach. The lower reach is located in an area heavily influenced by tidal action. Bottom material is composed of sand, silt, and organic matter. The 41 samples collected at mile 18.8, mile 12.8, and mile 4.0 were used to characterize this reach. This reach contained approximately two-thirds as many organisms per square foot as the upper reach, but the volume of these organisms was just over one-half as much as those from the upper reach. Numbers and volume, however, were greater in this reach than in either of the middle reaches. There were few kinds of different organisms present. Most of those collected were clams, amphipods, oligochaetes, and midge larvae.

Seasonal Variations

Detailed seasonal variations in population density and composition have not been evaluated. An examination of the total numbers of organisms during each month at the twelve selected stations indicates that sampling error can account for a large amount of variation (Table 17). Results at the stations during April, May, and June 1960 are considerably different from those during the same months in 1961.

There was a significant change in numbers over the period of study in the upper reach. From a low average number of 47.5 organisms per square foot in July 1960, the populations built up to a high of 933.9 organisms per square foot in November 1960, and then dropped to 86.2 in December and 52.6 in January 1961. Heavy rains, resulting in high river flows, occurred in late November and may have been largely responsible for the decrease.

A corresponding decrease was observed in the upper-middle reach between November and December 1960. There was no comparable decrease in total numbers of organisms in the lower-middle and the lower reaches.

Discussion

The most important contribution of the biological phase of the Sacramento River Water Pollution Survey has been the collection of information concerning present biological conditions in the Sacramento River. The main value will be realized in future years when the effect of water quality degradation due to additional development in the Sacramento Valley can be quantitatively assessed.

An attempt has been made to select a limited number of animals that might possibly be used as potential environmental indicators. The selection of these organisms was based on the regularity and frequency with which they were collected. The adaptations and requirements of many of these organisms need to be determined.

Table 17

SACRAMENTO RIVER WATER POLLUTION SURVEY
NUMBERS OF BOTTOM ORGANISMS AT SELECTED STATIONS

Station	1960									1961						Average
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	
285.9	122.4	38.6	203.0	38.2	187.6	329.2	689.0	731.8	101.9	71.0	174.8	---	---	288.9	---	248.0
275.0	76.7	47.0	30.9	65.0	135.7	483.9	1,125.0	1,884.0	153.9	74.9	254.3	---	168.5	---	317.8	370.6
229.8	123.6	21.0	76.6	39.2	154.7	293.6	193.0	185.8	2.7	11.9	3.2	---	18.2	119.0	67.1	93.5
Average	107.8	35.5	103.5	47.5	159.7	368.9	669.0	933.9	86.2	52.6	144.1	---	93.3	203.9	192.5	233.4
217.6	68.0	136.5	40.5	24.0	9.8	34.6	20.4	21.9	5.5	---	39.1	---	21.0	---	35.4	38.1
199.6	0	4.0	243.0	80.4	46.5	37.5	192.0	34.5	---	---	---	9.1	---	132.0	---	66.0
168.2	79.2	6.0	15.5	10.6	17.3	75.3	48.0	15.0	---	8.3	---	10.7	---	24.0	---	28.2
Average	49.1	48.8	99.7	38.3	24.5	49.1	86.8	23.8	5.5	8.3	39.1	9.9	21.0	78.0	35.4	43.2
90.5	12.6	18.5	38.3	33.1	33.2	55.5	51.0	4.5	25.5	---	27.0	---	67.5	---	18.0	32.1
62.6	33.0	10.0	24.0	5.3	6.0	55.5	76.5	58.5	22.5	19.0	10.5	7.5	94.5	45.0	25.7	32.9
37.2	8.0	23.1	43.6	8.3	25.5	18.0	27.0	30.0	15.0	39.0	33.0	42.0	37.5	247.5	49.5	43.1
Average	17.9	17.2	35.3	15.6	21.9	43.0	51.5	31.0	21.0	29.0	23.5	24.7	66.5	146.2	31.1	36.3
18.8	0	1.0	4.0	9.9	35.3	48.0	67.0	159.0	141.0	135.0	106.5	2.3	18.0	43.5	22.5	48.8
12.8	10.5	97.6	42.4	78.0	132.0	118.5	153.0	186.0	222.0	---	147.0	---	121.5	---	126.0	119.5
4.0	---	135.0	40.5	261.0	235.5	298.5	379.5	170.0	246.0	351.0	592.5	352.5	136.5	153.0	319.5	262.2
Average	5.2	77.9	29.0	116.3	134.3	155.0	199.8	171.7	203.0	243.0	282.0	118.3	92.0	98.2	156.0	142.4

The animals described in this section are probably the most important ones to be studied in the future. If there should be a major change in numbers, or if any of them should disappear from the river, it would be an indication that some change in the chemical, physical, or biological conditions had occurred.

Annelida

Oligochaeta. The oligochaetes (worms) occur in both aquatic and terrestrial habitats. Members of this class were found throughout the length of the river. Specific identification of these animals is extremely difficult and positive recognition often necessitates performing serial sections. This was not possible during the present study.

Polychaeta. Most of the polychaetes are marine or estuarine, but a few are known from fresh water. *Neanthes limnicola* was found in the Sacramento River as far upstream as mile 81.5 (above Sacramento Slough). The greatest numbers, however, were found in the lower area of the river within the zone of tidal influences.

Crustacea

Amphipoda. A species of amphipod, *Corophium spinicorne*, was found from mile 118.1 to 4.0. This species is generally considered to be a salt or brackish water form, and has not been previously reported from fresh water.

Large numbers of *Corophium* were taken from the station located at mile 81.5. At this location the organisms were consistently found burrowed into the clay bottom. A few organisms were found at stations between mile 118.1 and mile 18.8, where it again was found in significant numbers. It was also present in large numbers at the two lowest stations.

Insecta

Trichoptera. The caddisflies are an order of insects that are indicators of clean water with high dissolved oxygen content. They undergo complete metamorphosis, progressing from egg to larvae to pupae to adult. Four genera were selected as possible indicator organisms.

Ochrotrichia belongs to the family Hydroptilidae, the "Microcaddis". All members of this family are small. They build a tiny (2-4 mm.) case, shaped like a flattened bean, and slit at each end. The case is usually constructed of silk with sand or minute bits of rock adhering to the exterior. When ready to pupate, the individual closes the slits at each end and completes its metamorphosis.

Hydropsyche belongs to the family Hydropsychidae. This organism builds a net which it attaches to rocks or twigs so that the opening is perpendicular to the stream flow. After constructing the net, the larvae retreats into the bag of the net or under some nearby rock to await food particles which are swept onto the net. Hydropsyche is an omnivore, consuming anything that is edible. When this organism is ready to pupate, an elliptical dome-shaped cocoon is spun with pebbles and bits of rock neatly fitted to the exterior. Only the bottom which is glued to a large rock is left unadorned.

Agapetus is a member of the family Glossosomatidae. This animal builds a case shaped much like a turtle shell out of small stones. The elliptical dome-shaped case, with a flat bottom, has a bridge of small stones across the underside which leaves an opening at each end. Agapetus extends head and legs out one end and posterior prolegs or anal claws out the other and crawls along the surface of larger stones feeding on the algae and mosses growing there. When ready to pupate, Agapetus cuts away the bridge at the bottom of its case and carefully seals the case to a large stone. Inside, a reddish brown, bean-shaped chitenized covering encloses the larva. How this develops is unknown, but presumably the larva secretes this material. One quick method of determining which pupal case contains either Hydropsyche or Agapetus, since their cases are very similar in appearance, is this chitenized covering. Hydropsyche, as previously stated, spins a cocoon of silken fibers, and the difference between the two cases is at once apparent from the underside.

Lepidostoma belongs to the family Lepidostomatidae. This animal constructs a case that is a circular tapered tube of sand grains when quite small. As the animal grows, however, flat particles of plant material are substituted for sand, and the case becomes square in cross-section. Contrasted with Agapetus, Lepidostoma has only the head and legs free, while the anal claws secure the animal to its case. At pupation, each end of the case is sealed with plant and stone material bound together with silk.

Ochrotrichia and Lepidostoma are found in greatest numbers in the upper area of the upper reach (above mile 279.2), but also occur at all the riffle stations. Agapetus apparently does best in the central area of the upper reach (mile 279.2 to 253.4), and Hydropsyche occurs more frequently in central to lower portions of the upper reach (mile 279.2 to 229.8). Hydropsyche pupae were found during each month of the survey, although they were most prevalent between May and September.

Agapetus pupae were found during each month except July. From a gross analysis of the data, more specimens of Agapetus seem to be in the pupal stage during the winter months, and probably a greater proportion of these animals emerge in early spring.

Occasionally other Trichoptera, including *Psychomyia*, *Brachycentrus*, *Leptocerus*, *Leptocella*, and *Polycentropus* were found.

Plecoptera. The stoneflies are an ancient, primitive order of insects which undergo incomplete metamorphosis. The succession is egg to nymph to adult. All of the nymphs of this order are aquatic, and all but a few require running water for their development. The development from egg through adult may take from one to three years. Most stonefly numphs are phytophagus, or plant eaters, but members of the family Perlodidae are carnivorous. This order of insects indicates cold, clean water conditions. Stations at miles 256.3, 241, and 229.8 produced the greatest numbers of species and individuals.

The family Pteronarcidae is represented in California by two species, *Pteronarcys californica* and *P. princeps*. These are extremely large-sized nymphs (up to two inches), and their immature stages may take two or three years for complete development. The species found during the present survey was probably *P. californica*.

The two dominant members of the family Perlodidae found during the survey were of the genus *Isogenus*. One of these, *Isogenus* (*Isogenoides*) has not previously been reported from California.

Members of the family Nemouridae are phytophagous. The nymphs of the several subfamilies are difficult to identify, especially the Capniinae. They are primarily small, winter-emerging species. The taxonomic problems are greatly increased when adults as well as immatures are not collected.

Diptera. The true flies are one of the largest and most diverse of the orders of insects. As is apparent by the name, its members are typified by the presence of two wings. Ordinarily, Diptera develop through complete metamorphasis, egg to larva to pupa to adult. Approximately 50 percent of this order have aquatic stages in their life cycle, and many of these are important fish-food organisms.

Tanyderidae. A most unusual larva was discovered during the course of the survey. At mile 229.8 the larva of *Protanyderus sp.*, the immature stages of which have never previously been reported, were found with great regularity. A diligent, but unsuccessful, effort was made to locate the pupal form. This is an archaic or prototype crane-fly, the larvae of which are similar to those of *Protoplasa fitchii*, the only previously recorded larva in this rare family. *Protanyderus* is characterized by a fully sclerotized head capsule, long prolegs with retractable claws at the posterior end only, but most striking are the six long filaments at the caudal end of the body. In February 1961, one of these larvae was collected that appeared to be commencing pupation. Unfortunately, high flows in the river the succeeding two months did not permit sampling at this station. By April only relatively small individuals were present.

Tipulidae. Most of the crane flies are semi-aquatic or terrestrial in their immature stages, but a few such as *Antocha* and *Hexatoma* are strictly aquatic. Only a single genus (*Antocha*) of this family was collected with any degree of regularity, and the pupa of this animal is different from any previously described in that the first branch of the respiratory organ is swollen and curves around to the front rather than pointing upward. Johannsen (1934) reports that members of this genus construct larval cases. No silken larval cases were discovered in this survey but the pupae occurred in stone-covered silk cocoons with the underside bare of stones, and the anterior end open so that the respiratory organs protrude. The larvae feed mainly on algae. They were most commonly found from mile 285.9 to mile 229.8.

Simulidae. The black flies are phytophagous in their larval stages. The larvae have a fan of hairs around the mouth with which to brush bits and pieces of plant material toward the mouth. Near the anterior end are prolegs which enable the animal to move about. At the posterior portion of the abdomen is a sucker-like disc surrounded by rows of hooks. The function of this disc is to assist the animal to retain its position on a rock in rapid water. The pupa is partially ensheathed in a cocoon and normally the respiratory organs extend out of the pupal case. Some species of this family have been characterized as pollution indicators,but most of this group is found in rapidly flowing waters with high dissolved oxygen content. In some trout streams, animals may be sufficiently numerous to make rock surfaces slippery and hazardous to anglers.

Tendipedidae. The midges are one of the most diverse groups in the order Diptera. Four of the six subfamilies were collected from the Sacramento River. Only Podonominae, restricted to high mountain country, and Clunioninae, which is almost exclusively a marine, were not seen. The larvae of these animals occupy a wide range of terrestrial and aquatic habitats. Certain species tend to be confined to particular environments. Greater knowledge of life histories and physical and chemical requirements, members of this group may be useful as pollution indicators.

Diamesinae. The immature stages of this subfamily are primarily cold water inhabitants and are phytophagous. Several species of this group were found in riffle areas. They have not previously been recorded in California.

Tendipedinae. Members of this subfamily, particularly _Tendipes plumosus_, have frequently been identified as pollution indicators. However, this species occurred in obviously unpolluted water at Redding (mile 295.5).

In the Sacramento River, _Calopsectra_ was found in the riffle areas. Members of this genus are phytophagous. They spin a horn-shaped case which holds a fine web for collecting algae and detritus for food. The posterior portion of the case is anchored to a rock for about one quarter of its length, while the remainder usually turns upwards and faces the current. At pupation, the open end is covered with silk, except for a small hole in the middle which permits the exposure of the pupal respiratory organs.

The larvae and pupae of several species of _Cryptochironomus_ were found regularly, but one deserves particular notice. The immature stage of this species certainly, and the adult in all probability, remain undescribed. The toxonomic distinctiveness of this individual makes it recognizable at a glance. The antennae are quite long, and the antennal blade arises at the distal part of the second segment. The maxillary palpi are equally as long as the antennae, lending the first impression of two pairs of antennae. The anterior pair of prolegs does not appear to be present, but rather appears as two brown longitudinal rods interior to the integument on the prothoracic segment. The posterior prolegs are usually long with extremely fine claws which are in most instances retracted so as to be discerned only with careful examination.

Ecologically, this species seems to be one of four of the Tendipedidae which has been able to adapt to life in the grinding, shifting sands of the river bed load, and this one is found most regularly. The others are members of the following genera: *Pentapedilum*, *Polypedilum*, and *Cricotopus*. Most members of the genus *Cryptochironomus* are found in slower moving waters, and some are miners in the stems and leaves of aquatic plants.

Larvae and pupae of *Pentapedilum* and *Polypedilum* were found most regularly in the upper-middle reach and occasionally in the lower-middle reach.

Mollusca

Pelecypoda. The asiatic clam *Corbicula fluminea*, has become a serious pest in certain California rivers and canal systems. There did not appear to be any thick beds of these clams in the Sacramento River such as occur in some other streams and canals. *Corbicula* does, however, appear to be able to maintain a significant population under severe conditions of a moving bed load and was found as far upstream as mile 90.5 and in Colusa Basin Drain (mile 90.2R). Far greater numbers of small individuals were found than full grown clams. It is possible that as yet undiscovered concentrations of these individuals exist in the river, or the population is just beginning to bloom. At any rate, it will be important to follow the development of this population of small clams.

Future Work

The identification of several of the groups of animals presented serious difficulties. It is probable that some of the organisms have not yet been described.

The life histories and environmental requirements of many of the species are imperfectly known. Increased knowledge in this respect would be tremendously important in selecting indicator organisms for assessing water quality.

Additional work is warranted to give a better understanding of the existing conditions in the Sacramento River. A tremendous amount of data was collected during this survey. An evaluation should be made of the many physical conditions, such as flow, temperature, dissolved oxygen, etc., and their relationships to the biology of the river. This includes both benthic organisms and plankton.

It is expected that taxonomic information and data on range extensions and ecology will be reported in Department of Fish and Game publications or other technical journals.

Future biological monitoring of the Sacramento River is necessary to detect changes in the river environment. In view of the presently anticipated development of the Sacramento Valley, it is suggested that comprehensive investigations be made at intervals of about five years. Such investigations may be restricted to 10 or 12 stations occupied seasonally.

The extreme variability of the dissolved oxygen content of water in gravels is a factor that warrants further investigation. Adequate dissolved oxygen is particularly important in development of salmon and steelhead eggs in the gravel riffles.

CHAPTER V. SUMMARY AND RECOMMENDATIONS

A study of the biological conditions in the Sacramento River was made over the period April 1960 through June 1961. The purposes were to establish a "base line" of present conditions, provide the basis against which future changes can be measured, and provide information for use in setting appropriate requirements for present and future waste discharges.

Summary

Water temperatures in Keswick Reservoir were relatively constant throughout the period of investigation (50 - 55°F). During winter months, temperatures decrease as the water moves downstream. Temperatures rise below Keswick during the remainder of the year and reach highest values just above Sacramento.

Dissolved oxygen concentrations are high in the upper reach and gradually decrease throughout the length of the river. Large variations of dissolved oxygen were found at closely spaced sampling points at several of the riffle stations. In the gravels, the lower oxygen levels were usually associated with higher silt concentrations.

The transparency of water in the Sacramento River generally decreased from the upper area to the mouth.

Attached plants are uncommon in the river proper. A species of moss (*Fissideus*) is present in the riffles in the upper section of the river. Emergents such as *Typha* and *Scirpus* are present along the banks in the lower sections. Benthic algae are present in the riffles in the upper reach of the river, but were rarely found in other areas.

At least 165 separate species of animals, representing 10 phyla, were collected from 29 river stations during the survey. The dominant organisms were oligochaetes (worms) and insects. Most of the latter were immature stages of the orders Diptera (flies) and Trichoptera (caddisflies).

The river was divided into four major environments.

The upper reach of the river (above mile 229) was characterized by animals which inhabit clean, fast-flowing water, such as caddishflies, mayflies, stoneflies, true flies, and oligochaetes. This reach contained the greatest average number of organisms, average numbers of genera, and average volumes of organisms per square foot of sampled area.

The lower reach (mile 18.8 to mouth of river) was the next most productive area. This reach contained primarily clams, amphipods, oligochaetes and midge larvae.

The two middle reaches were relatively unproductive. Most of the organisms collected were oligochaetes, midge larvae, and clams.

One large seasonal variation in animal abundance was noted. Production of bottom organisms steadily increased from July through November 1960 in the reach above mile 229. A sharp drop in numbers was noted in December 1960 and January 1961. This drop in numbers followed very high river flows in late November.

Recommendations

1. Knowledge of the taxonomy and life histories of many of the organisms collected during the survey should be expanded.

2. A more complete evaluation should be made of the data collected during the Sacramento River Water Pollution Survey in order to establish the relationships between biological populations and their environments.

3. Future biological monitoring of the Sacramento River should be done at intervals of about five years. Ten or 12 stations should be sampled intensively during each season of the year.

Local studies, in connection with specific waste discharges or problems, must be scheduled as needed.

4. The causes and significance of variations in dissolved oxygen within stream gravels should be determined.

5. Future investigations should be planned so that adequate time is available to evaluate the data and write the report. It is suggested that from three to five man-days of laboratory time be provided for each man-day spent in the field. In addition, a minimum of two man-days of professional time in the office for each day in the field are required from the outset of the investigation for evaluation of the data, and at least two more man-days are required during the final evaluation and report-writing stage.

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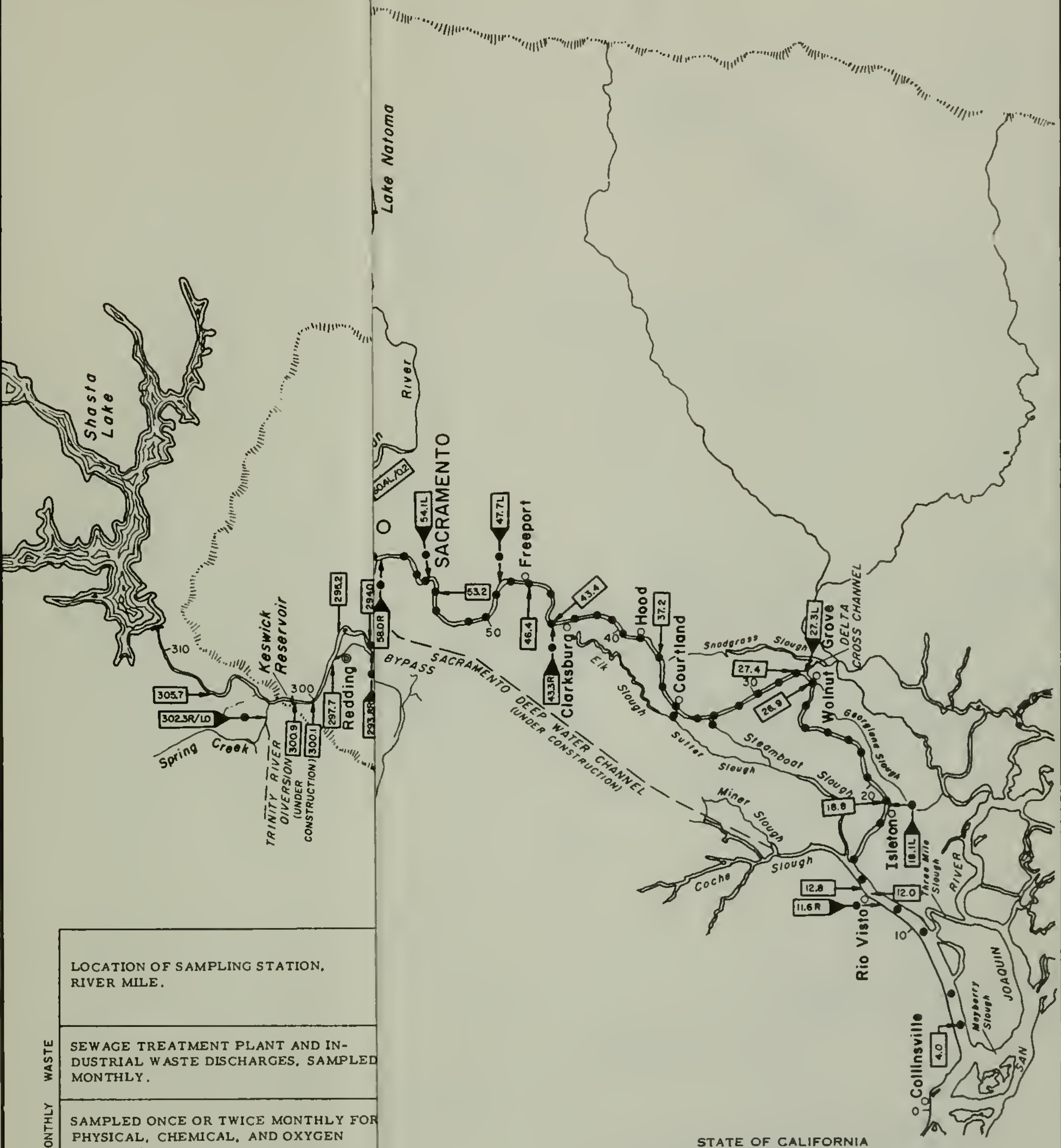

	LOCATION OF SAMPLING STATION, RIVER MILE.
WASTE	SEWAGE TREATMENT PLANT AND INDUSTRIAL WASTE DISCHARGES, SAMPLED MONTHLY.
MONTHLY	SAMPLED ONCE OR TWICE MONTHLY FOR PHYSICAL, CHEMICAL, AND OXYGEN ANALYSES.
DAILY	SAMPLED MONTHLY OR BIMONTHLY FOR PLANKTON, BOTTOM ORGANISMS, SEDIMENT GRADATION, DISSOLVED OXYGEN AND TEMPERATURE.
BIOLOGIC	SAMPLED DAILY FOR TEMPERATURE AND ELECTRICAL CONDUCTANCE. CHEMICAL ANALYSES OF COMPOSITE SAMPLES.
ORGANIC	PERIODIC ORGANIC ANALYSES SAMPLING USING CARBON ADSORPTION METHOD.
E.C.	CONTINUOUS ELECTRICAL CONDUCTIVITY RECORDER.

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH

SACRAMENTO RIVER WATER POLLUTION SURVEY

SAMPLING PROGRAM
AND
AREA OF INVESTIGATION
1960-61

SCALE IN MILES
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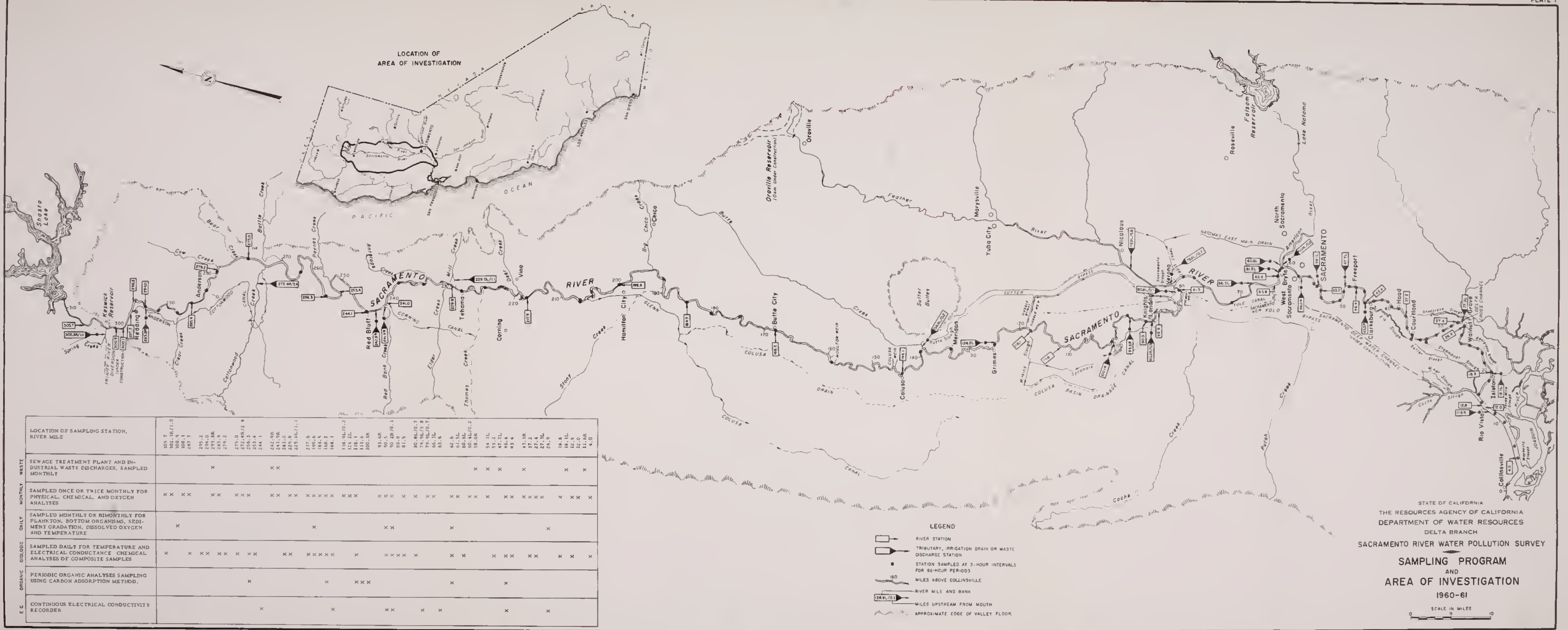

	LOCATION OF SAMPLING STATION, RIVER MILE	305.7	302.3R/1.0	300.9	300.1	297.7	295.2	294.0	293.5R	285.9	279.2	275.0	272.4R/2.4	256.3	253.4	244.1	242.9R	241.9R	241.0	229.8	229.0L/1.1
WASTE	SEWAGE TREATMENT PLANT AND INDUSTRIAL WASTE DISCHARGES, SAMPLED MONTHLY								×								×	×			
MONTHLY	SAMPLED ONCE OR TWICE MONTHLY FOR PHYSICAL, CHEMICAL, AND OXYGEN ANALYSES	×	×		×	×			×	×		×	×	×			×	×		×	×
DAILY	SAMPLED MONTHLY OR BIMONTHLY FOR PLANKTON, BOTTOM ORGANISMS, SEDIMENT GRADATION, DISSOLVED OXYGEN AND TEMPERATURE			×																	
BIOLOGIC	SAMPLED DAILY FOR TEMPERATURE AND ELECTRICAL CONDUCTANCE. CHEMICAL ANALYSES OF COMPOSITE SAMPLES	×				×	×	×		×	×	×		×	×				×	×	
ORGANIC	PERIODIC ORGANIC ANALYSES SAMPLING USING CARBON ADSORPTION METHOD.													×							
E.C.	CONTINUOUS ELECTRICAL CONDUCTIVITY RECORDER															×					

	LOCATION OF SAMPLING STATION, RIVER MILE	217.6	199.6	184.5	168.2	164.1	138.9L/0.2	124.2L	118.1	111.6	100.1R	93.6R	90.5	90.2R/0.1	88.8	81.5	80.8L/0.7	74.9L/5.8	79.9L/0.7	66.3L	63.6
WASTE	SEWAGE TREATMENT PLANT AND INDUSTRIAL WASTE DISCHARGES, SAMPLED MONTHLY																				
MONTHLY	SAMPLED ONCE OR TWICE MONTHLY FOR PHYSICAL, CHEMICAL, AND OXYGEN ANALYSES	×	×	×	×	×	×	×	×			×	×	×		×	×		×	×	
DAILY	SAMPLED MONTHLY OR BIMONTHLY FOR PLANKTON, BOTTOM ORGANISMS, SEDIMENT GRADATION, DISSOLVED OXYGEN AND TEMPERATURE		×										×	×							
BIOLOGIC	SAMPLED DAILY FOR TEMPERATURE AND ELECTRICAL CONDUCTANCE. CHEMICAL ANALYSES OF COMPOSITE SAMPLES	×	×	×	×	×			×				×	×	×	×	×				
ORGANIC	PERIODIC ORGANIC ANALYSES SAMPLING USING CARBON ADSORPTION METHOD.				×				×	×	×										
E.C.	CONTINUOUS ELECTRICAL CONDUCTIVITY RECORDER					×							×	×				×			×

	LOCATION OF SAMPLING STATION, RIVER MILE	62.6	61.5L	60.6L	60.4L/0.2	58.0R	54.1L	53.2	47.7L	46.4	43.4	43.3R	37.2	27.4	27.3L	26.9	18.8	18.1L	12.8	12.0	11.6R	4.0
WASTE	SEWAGE TREATMENT PLANT AND INDUSTRIAL WASTE DISCHARGES, SAMPLED MONTHLY					×	×		×			×						×			×	
MONTHLY	SAMPLED ONCE OR TWICE MONTHLY FOR PHYSICAL, CHEMICAL, AND OXYGEN ANALYSES	×	×		×	×	×			×	×	×	×	×	×		×		×	×		×
DAILY	SAMPLED MONTHLY OR BIMONTHLY FOR PLANKTON, BOTTOM ORGANISMS, SEDIMENT GRADATION, DISSOLVED OXYGEN AND TEMPERATURE	×														×						
BIOLOGIC	SAMPLED DAILY FOR TEMPERATURE AND ELECTRICAL CONDUCTANCE. CHEMICAL ANALYSES OF COMPOSITE SAMPLES	×		×				×		×	×		×	×			×		×			×
ORGANIC	PERIODIC ORGANIC ANALYSES SAMPLING USING CARBON ADSORPTION METHOD.	×								×												
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